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The idea is that all this kit will bring PC gaming into the living room, but that strategy opens up Valve to competition from all angles. The PS4 and Xbox One are the current kings of the couch, and PC Windows has a much wider games catalogue than Linux too. In this issue, we spend some quality time living with SteamOS, playing games on the new Steam Controller and trying out two Steam Machines, to see if Valve can really carve a corner for itself in the lounge.

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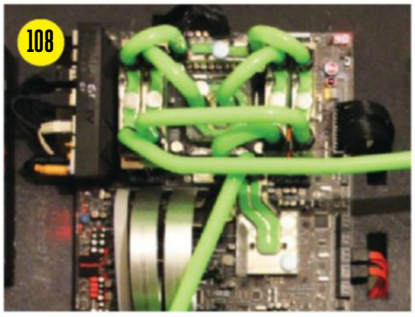

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Cyberpower recommends Windows.

Windows 10

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BEN HARDWIDGE / FROM THE EDITOR

HOW IMPORTANT IS EFFICIENCY?

Power efficiency might not have the instant appeal of superior graphics and performance, but we should take it seriously, argues Ben Hardwidge

Efficiency just isn't sexy. I've watched marketing managers try to talk enthusiastically about performance per watt, and it must be like trying to get excited about loft insulation. Better graphics are cool. Faster computers are cool. Even bragging rights are cool. But lower power consumption? It's tough, because there's no immediately visible benefit.

But while efficiency might not be the stuff of hardware geek fantasies, it's a major factor when it comes to my buying decisions. While we were sorting out the scoring system for last month's GPU Labs test, we settled on a 10 per cent score for efficiency again, but I wonder if that's enough now. There's a gulf between Nvidia and AMD's GPUs when it comes to power efficiency, where our test system drew 266W from the mains with a GeForce GTX 970 installed at load, but that figure rocketed up to 437W with a Radeon R9 390 in place. That's a difference of 171W, and it will increase further as you add more cards.

> It must be like trying to get excited about loft insulation

Efficiency now concerns differences of hundreds of watts, and for very similar performance. Aside from any concerns about your carbon footprint, that's bad news if you're a PC gamer. With the higher heat output of non-efficient hardware, you'll need more powerful and often noisier coolers, as well as more airflow in your case to help expel the hot air. It also limits how much hardware you can install in your case. I wouldn't want three Radeon R9 390X cards in my system without some decent space between them for airflow.

Poor efficiency also limits what board partners can do with hardware, such as making small cards with small coolers. What's more, it limits your choice of system. You could comfortably build a tiny GTX 970 rig with an SFX PSU, but not with an R9 390.

Then there's the cost of electricity, and once you get into this territory it stops being negligible, particularly if you use your PC for gaming a lot. Choosing an R9 380 over a GTX 970 is almost like leaving an extra three 60W lights on in the house while you're gaming.

GPUs aren't the only issue. CPUs can also eat a lot of electricity at full whack. Intel has nailed efficiency with its latest Skylake kit, with CPUs such as the Core i3-6100T having a TDP of just 35W, making it ideal for our HTPC build (see p88). Likewise, the Core i7-6700K's TDP is only 91W, which is an amazing achievement compared with the 220W TDPs of AMD's top-end FX CPUs.

Efficiency is AMD's big problem at the moment, partly because it's still depending on a GPU architecture that's nearly four years old, but AMD also seems to be dismissing efficiency as unimportant. In terms of performance and features, AMD's kit is still competitive, but that isn't enough now. When I look at what hardware to buy, I'm also thinking about the heat output and power consumption, particularly when the differences involve hundreds of watts.

For me, efficiency is now a major factor when it comes to buying decisions, even if it isn't particularly exciting, but I'm often told that enthusiasts don't care, and that performance and frame rates are the priorities. Is this true? Do PC enthusiasts really not care about heat output and power consumption? I find it very hard to believe, and I'd be interested in your thoughts. Drop me a line at letters@custompcmag.org.uk CPC

Ben Hardwidge is the editor of Custom PC. He likes PCs, heavy metal, real ale and Warhammer 40,000. editor@custompcmag.org.uk @custompcmag

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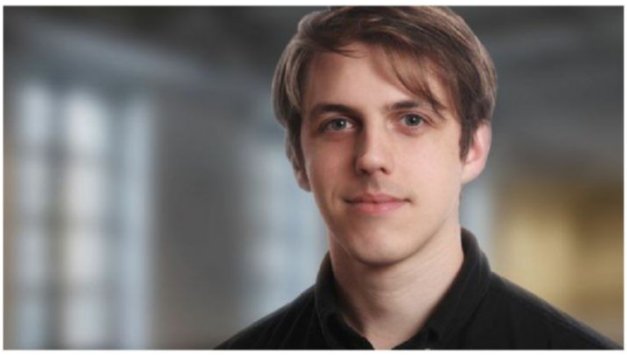

RICHARD SWINBURNE / VIEW FROM TAIWAN

NBASE-T FOR THE HOME

It's time for home users to get a faster Ethernet standard, rather than more over the top Wi-Fi kit, argues Richard Swinburne

NBase-T is a new specification designed to bridge the gap between Gigabit Ethernet and enterprise-centric 10 Gigabit (10GbE) standard, which typically uses optical fibre and costs big wads of cash. The NBase-T spec calls for bandwidths of 2.5Gb/sec and 5Gb/sec – a significant upgrade – while retaining the use of the CAT5e/6 spec cabling that's ubiquitous in homes and small to medium businesses. The specification states that these speeds should be possible at up to 100m over copper wire, making it an ideal upgrade.

At the moment, though, Wi-Fi is getting all the investment, with routers sporting extreme speeds, such as AC3200+, although admittedly, those speeds are technically not true per-user. There have also been big advancements in beam-forming, with Wi-Fi kit featuring six, eight and even 13(!) antennae, while MU-MIMO technology yields superior performance and signal reliability.

In the process, wired Ethernet development has been foolishly sidelined. You can never be 100 per cent sure what you'll get from a wireless router signal, where the faster speeds are only attained using the distance-limited 5GHz band. Also, while 802.11ac routers are very popular in the USA, in the UK (and EU) where we typically have brick walls and denser housing (so we can see half a street's worth of hotspots), I'd argue that wired Ethernet is still preferable for many people.

Gigabit Ethernet delivers roughly 100MB/sec in terms of real-world throughput, depending on cabling quality, router performance and the speeds of source/destination drives. As SSD prices hit the deck, though, and more people dump their hard disks, this 100MB/sec throughput will quickly become a bottleneck.

This year, 1TB SSDs have dropped in price significantly, and Samsung's 950 SSDs will even have a 2TB option.

> As SSD prices hit the deck, 100MB/sec will soon be a bottleneck

By 2017, we'll see up to 6TB of flash memory packed into 2.5in boxes, meaning that SSDs will quickly begin to replace NAS hard drives as well. And so they should – their fast bootup capability, low power, zero noise and smaller size are perfect for an always-on device. With SSD-to-SSD transfers due to become the norm in the near future, 5GbE NBase-T will be an essential upgrade to give us 500MB/sec throughput.

The problem is that the NBase-T Alliance (**www.nbaset.org**) was created with enterprise in mind, and the tech has been sold as a good-value *downgrade* option for 10GbE, rather than an upgrade path to 1GbE. It's hardly surprising, since the NBase-T Alliance Chairman works at Cisco, although the working group has grown to 34 members this year, including Intel, Realtek, Marvell and Qualcomm – companies that all make kit in typical home routers and motherboards. However, even though the 1.1 spec has been released, no one is pushing NBase-T to its fuller potential in the home and small to medium business markets.

Intel recently launched new Xeon D processors for networking and data storage that are NBase-T compatible, but again, the tech is just a footnote when the premium spec has half a dozen 100GbE links. In addition, along with its new Maximus VIII Extreme/Assembly motherboard, Asus ROG also showed off its 10G Express card – a 10GbE add-on. Yet with no router to complement it (at the time of writing), and the motherboard costing $500 US (£329), this technology is clearly for the very few.

With enterprise networking and home networking having significantly different requirements, and often different design teams, the enterprise-centric developers have clearly forgotten us at home. However, NBase-T is an ideal and soon to be needed upgrade – let's make some noise and demand it. **CPC**

Richard has worked in tech for over a decade, as a UK journalist, on Asus' ROG team and now as an industry analyst based in Taiwan @Bindibadgi

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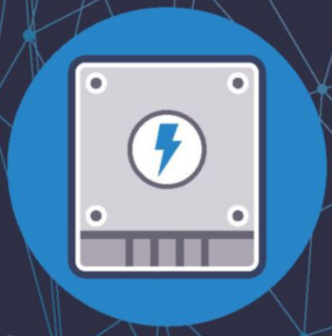

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Letters

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What goes surround, comes surround

Thanks for a great year of **Custom PC**. Following on from your recent review of the new Asus Strix sound cards, I wanted to ask for something to be cleared up. I've been helping out a friend recently with sound cards. He bought a Creative Sound Blaster Z and was looking forward to an improvement in his in-game sound.

Being an FPS player, he was looking for positional awareness and thought 7.1 would be really helpful, so he asked me to find him a 7.1 headset.

Therein lies the problem though – 7.1 headsets, it seems, mostly use virtual surround sound. They're stereo headsets with some processing built into the USB connector, coupled with software on the PC. Many don't have a standard 3.5mm jack, just using USB instead. Those that do have a jack, such as the HyperX Cloud II, use a single 4-pole 3.5mm jack (for use with a mobile phone), rather than the separate microphone and stereo jacks that sound cards need.

Meanwhile, headsets with true 7.1 surround, such as the Asus Strix 7.1, are USB-drive, so they bypass the sound card entirely. It all seems confusing that there are good quality sound cards out there, but a lack of gaming headsets that can use them. My recommendation to him looks like it's going to be to buy a decent pair of studio headphones and a separate microphone, then let the sound card and software do the virtual surround bit. Am I right?

Thanks guys, and keep up the good work. I'm looking forward to mince pie megatest – hope you have your indigestion tablets ready!

CHRIS HOLLOWAY

Asus' Strix 7.1 headset offers true positional audio, but only over USB

Ben: If your friend wants 7.1 sound from a headset, his best bet is to buy an Asus Strix 7.1 and bypass the sound card – the sound quality from that headset's USB DAC is great and the headset provides proper positional audio, rather than just virtual surround. I agree that it's a shame so many headsets don't give you the option to use your sound card's outputs though. For me, the main benefit of using a discrete sound card is the DAC quality, and there's no way to pass that through USB.

PEDANTS' PARADISE

Super-cheap SSD!

In Issue 148, on p89, there's either a typo or the best giveaway ever. Under the Storage heading, the Crucial BX100 500GB SSD is shown as having a price of £25!

If that's correct then a RAID 5 array is in the offing! I fear I'm going to be a bit disappointed when I go to **www.ebuyer.com**, however.

JONATHAN N PALMER

@bjhurdman Is it me or are 500GB SSDs coming down in price @CustomPCMag?

NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£55
Crucial BX100 250GB	www.ebuyer.com	Issue 141, p43	£65
Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£25
Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£280

Ben: Yes, that should have £125, rather than £25, although that's still a pretty good deal for a decent 500GB SSD! Sorry for the confusion.

Remounting your PSU

After reading issue 148 of **CPC**, I thought it would be best brought to bring your attention to the potential hazards of relocating the PSU mount and connections in your PC's case. While the instructions provided were clear to an extent, I noticed that p107 instructed readers on how to incorrectly connect a female IEC socket. Naturally, most people attempting this task would solder or (more suitably) use a spade connection to the pins on the back of the socket, followed by sheathing in an adhesive-lined heatshrinkable sleeving.

The picture does appear to show the flex twisted around the pins with a liberally applied sheath of insulation tape to support these connections, and no hint of the application of solder or crimped on spade connections. One can argue that this method of connection isn't suitable for the task at hand and, more to the point, potentially dangerous – chuck a couple of AMD Fury X cards in that rig and that connection could be seeing a fair few amps flowing through it.

YOUR FRIENDLY ELECTRICIAN, MATTHEW VOISEY

Antony: Hi Matthew, thanks for letting us know the error of our ways and offering some expert advice! We'll be revisiting this part of the guide in our next issue with some revised steps, using your advice about spade connections and heatshrink insulation sleeving. If anyone is thinking of conducting that mod, we advise holding off until Issue 150 before doing so.

Desktop vs workstation graphics

I love the magazine, and I've been subscriber for a while now. I know this topic has been

Twitter highlights

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Paulzzo Nvidia GeForce GTX 960 2GB – where can I get this card for from your printed £130 inc VAT price? Can't see it on Overclockers UK.
Ben: Sadly, it looks like it's no longer available at that price, which is always an issue with magazine reviews – we can only print the price that's correct when we go to press, and the price of components often fluctuates. The best price I can find at the moment for a GTX 960 card is £147 inc VAT at **www.box.co.uk**

l3pje Thanks @CustomPCMag such an honor!

Ben: It's a pleasure – that was a great build!

CrodthNebula Your review of the EK Predator 240 says it fits LGA775 sockets, but the spec on the manufacturer's site doesn't. Do you know something we don't?
Antony: It is indeed LGA115x and LGA2011-only on Intel – the reference to LGA775 was a mistake. Sorry about that!

H2OhPC I'm surprised that the 390X with 8GB of RAM did so poorly in your tests against 4GB and 6GB cards at 4K. Thanks for saving us a lot of time testing so thoroughly.
Ben: We've yet to see a significant advantage of more than 4GB of memory on a graphics card, even at 4K. The usual benefits of having more memory are being able to apply more in the way of features such as anti-aliasing and, as you say, not falling apart at higher resolutions. However, running games at 4K is currently so graphically demanding that the GPU usually becomes the limiting factor on a high-end card before the amount of memory – the speed of the memory, as shown by AMD's 4GB Fury cards, is a much bigger factor.

People often assume that more memory always equates to superior performance, but in the real world, this isn't always the case. There will be a time when 8GB of memory is necessary on a graphics card, but we're not there yet.

Kerrrash Say it isn't so! @CustomPCMag Is there no mince pie megatest this year? ;(;(

wellrandom Haha, I was reading the latest issue earlier & thought 'cool, nearly time for the Xmas mince pie review.' It says 'Xmas is here' :)

kajun_cheng Yes! It's that time of year again, where I refer to your recommendations and put on weight! You guys always make good choices :-)
Ben: I'm glad we can be of such good service at Christmas, and yes, the annual mince pie megatest is now here – turn to p30 to find out which pies are worth your cash!

richardnpaul With m.2 SSDs like the 950 Pro, can I use them in my laptop's mSATA slots, assuming physical compatibility?
Ben: Sadly not, mSATA and M.2 use completely different connectors, but your question is completely understandable, as M.2 is a confusing shambles at the moment. We've gone into more detail about M.2 and next-generation storage standards in this issue on p42.

mentioned in the past, a long time ago, but I'm curious about the differences between desktop and workstation graphics cards, and if we should care. Why would anyone spend so much money on a card such as the Sapphire AMD FirePro W9000, even if they were a business professional?
TAYLOR GUZIEWICZ

Ben: As a general business professional, there's no point in buying a professional card – it won't do anything for basic spreadsheets or word processors – but they do have benefits for their specific niches.

Some professional cards are guaranteed to operate continuously under extreme pressure so that they can be used in compute-intensive environments.

If you're putting together a GPU-compute server with several graphics cards, you need to be sure that none of them are going to flake out after being continuously hammered – if you put a standard desktop graphics card in such an environment, it would likely die within days.

For these cards, only the most stable GPU and memory silicon samples can be used, and these samples are rare and expensive.

There are also professional cards for tasks such as 3D rendering and CAD, including support for features such as double precision, which aren't found on a desktop gaming graphics card. The markup on professional graphics cards is clearly huge in comparison to desktop graphics cards, but professional cards aren't just desktop cards with a super-high price tag – they have very specific benefits for their markets. CPC

Workstation graphics cards aren't cheap, but they're designed for different tasks from desktop gaming cards

WHEN'S THE NEXT MAG COMING OUT?
Issue 150 of **Custom PC** will be on sale on Thursday, 14 January, with subscribers receiving it a few days beforehand.

Send your feedback and correspondence to letters@custompcmag.org.uk

TRACY KING / SCEPTICAL ANALYSIS

GREAT SEXPECTATIONS

Are PC gamers really better lovers than console gamers? Tracy King puts on her best sceptical face

There's an experiment in which you play two videos simultaneously, each showing one person talking. You ask your subject to listen to one of the people speaking, and they will automatically tune out the other video until the person in that video says one of several words that grab attention.

The study demonstrates that we can hear things even when we aren't explicitly listening, or when we're concentrating on other speech entirely. It's solid science because you can prove the shift of attention using eye-tracking. Not surprisingly, one of the words that grabs our subconscious attention is 'sex'.

The old cliché that men think about sex every seven seconds isn't true, of course. Men don't think about sex as much as claimed, and women think about sex more than men realise. The truth is probably somewhere in between. Or at least, that's the best guess from the research available. There's a major problem with any study about 'what people think' because you can't usually objectively verify the data.

The process involves self-reporting, and there's no way of asking someone to report every time they think about a particular subject without the risk of biasing them. If you know you have to press a button every time you think about bears, for example, you're likely to either think way more about bears, or avoid thinking about bears because you don't want to press the button. When it comes to sex, you also involve a bunch of social pressures about gender roles and expectations, which makes it difficult to measure how frequently anyone thinks about a particular subject.

So when the media reports on a study that says PC gamers are 'better in bed' than console gamers, we have to take it with a rather large pinch of lube. One news site reported it as: 'PC players better in bed than PlayStation and Xbox rivals, study finds' – wording that pits platform users as 'rivals,' presumably for the sake of baiting clicks. But if you're tempted to take the bait and think of yourself as the superior lover, you'll have to look for evidence elsewhere.

For a start, the study was undertaken by discount website MyVoucherCodes. That alone means it probably isn't subject to rigid methodology. The company claims to have polled 2,474 'partners of gamers' in the UK (I don't know how or where, as the data isn't online and I didn't get a reply to my request for it). Those people were asked which gaming platform their partner used and to rate the other half in bed. Apparently, 54 per cent of PC gamers were rated 'good or above' compared to 47 per cent of Xbox gamers.

> It may be that 2,400 of them were Xbox users and only a handful were PC users, or vice versa

The quoted statistics for PlayStation users are only for 'excellent' (3 per cent) and 'very good' (8 per cent). We don't have the data for PlayStation users who are rated 'good', and I'd hazard a guess that this omission is because it takes the total to roughly the same as PC and Xbox gamers, and therefore ruins the story. In addition, we have no idea how many of the respondents' partners use each platform.

It may be that 2,400 of them were Xbox users and only a handful were PC users, or vice versa. And of course, the most important element – as with all studies on 'what people think' – is that this study relies on (presumably anonymous) self-reporting. People make up stuff. The final statistic reported is that 11 per cent of respondents wanted their partners to spend *less* time on sex and more on gaming. That is so unlikely I think I need to go and lie down. **CPC**

Gamer and science enthusiast Tracy King dissects the evidence and statistics behind popular media stories surrounding tech and gaming @tkingdoll

Incoming

We take a look at the latest newly announced products

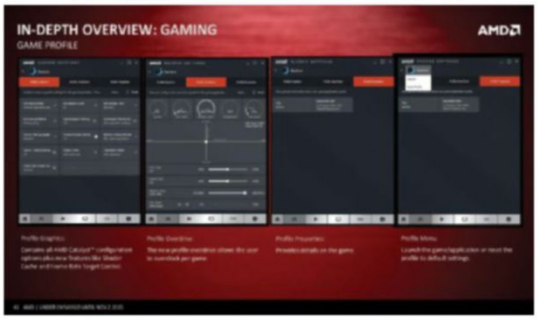
AMD releases Radeon R9 380X

In the ever-expanding numbers battle to make sure every possible niche segment of the graphics card market is covered, AMD has just released another member of its Radeon R9 300-series, the 380X. As with all of AMD's current GPUs, the 380X's Antigua XT core is based on the aging Graphics Core Next architecture – in this case, the 1.2 variant that was first seen with the Radeon R9 285 last year.

The 970MHz GPU has 2,048 stream processors, 128 texture units and 32 ROPs, and sits between the Radeon R9 380 and 390 chips in terms of specs. As standard, Radeon R9 380X cards will have 4GB of GDDR5 memory clocked at 5.7GHz (effective). Radeon R9 380X cards start at £189 inc VAT on **www.overclockers.co.uk**. Look out for a full review of the Radeon R9 380X in our next issue.

New Radeon driver software available

Over a decade after first releasing the Catalyst Control Center, AMD's graphics division has launched a new software suite for its GPU drivers. AMD claims its new Radeon Software Crimson Edition suite's startup time is up to ten times quicker than its predecessor, and that it can initialise displays in up to triple the speed of the Catalyst software too. Various other features are touted by the company too, including faster game load times, better stability, improved game performance and new sections for Overdrive and EyeFinity. The new software suite can be downloaded from **http://support.amd.com/en-us/download**



NUCs get Skylake treatment

Intel has updated its line-up of tiny Next Unit of Computing (NUC) gear to incorporate its new Skylake gear, introducing four bare bones systems. Two of the new systems use a dual-core Core i3-6100U CPU, which runs at 2.3GHz and features Hyper-Threading tech to process four threads simultaneously. This Core i3 chip also features 3MB cache, uses Intel's HD Graphics 520 system and has a TDP of 15W. The other two systems, meanwhile, feature a Core i5-6260U chip, which is also a dual-core CPU with Hyper-Threading, but its top Turbo speed is 2.9GHz and it's equipped with 4MB of cache and Intel's Iris Graphics 540 system.

The bare bones systems will also feature a load of connections, including 802.11ac Wi-Fi and Gigabit Ethernet as standard, along with four USB 3 ports, HDMI 1.4, mini-DisplayPort 1.2, M.2 2280/2240 connectors and support for up to 32GB of DDR4 RAM. Two of the models will also have room for a 2.5in drive in addition to an M.2 drive.

Corsair cools Nvidia GPUs

Corsair has announced some new cooling brackets that enable you to hook up various Nvidia graphics cards to the company's all-in-one liquid-cooling systems. You'll need to remove your graphics card's air cooler to install the new HG10 N970 or N980 aluminium brackets, which also feature a 70mm fan to help cool the rest of your card's components. With the bracket installed, you can then fit the pump/waterblock unit of one of Corsair's Hydro liquid coolers to the GPU.

The HG10 N970 is compatible with stock GeForce GTX 970 cards, while the N980 can be fitted to any GTX 980, 980 Ti or Titan X card that has a stock PCB layout. Both coolers have a recommended retail price of £30 inc VAT.

Reviews

Our in-depth analysis of the latest PC hardware

Reviewed this month

Corsair Strafe RGB p17 / Asus Sabertooth Z170 p18 / MSI Z170i Gaming Pro AC p20 /
Asus ROG Swift PG27AQ p24 / Vertagear Racing Series S-Line SL4000 Gaming Chair p26 /
NZXT HUE+ p27 / Cooler Master Xornet II p28 / Custom kit p29 / Mince pie megatest p30

HOW WE TEST
PAGE 34

MECHANICAL GAMING KEYBOARD

Corsair Strafe RGB / £140 inc VAT

SUPPLIER www.scan.co.uk / MODEL NUMBER CH-9000121-UK

As its name suggests, The Strafe RGB offers full RGB per-key backlighting, whereas the original Strafe only offered red lighting. This feature ties in to Corsair's Utility Engine software, which gives comprehensive control over the lighting effects of every key, in addition to other parts of the keyboard. The Strafe RGB also sports a reasonably large detachable wrist rest for extra comfort and a USB 2 pass-through port – both missing features on the cheaper non-RGB model. The USB pass-through is useful for connecting other desktop peripherals such as mice and headphones to your PC. Sadly, though, Corsair's excellent dedicated media controls and volume dials from the Vengeance K-series of keyboards are still absent from the Strafe RGB, as are dedicated macro keys.

The switches were noticeably quieter than standard switches

However, there's a far more significant addition to the keyboard – Cherry MX Silent switches. As with Cherry's RGB switches, Corsair and Cherry have a licence agreement allowing Corsair alone to use these new switches for the time being. They're aimed at fans of mechanical key action that are looking for quieter key presses, following feedback Corsair has sought from its community.

To make these new switches, standard Cherry MX Red and Black switches have been modified so that the switching slider inside them now features a TPE elastomer in the mechanism. This component not only reduces the bottoming out you experience with some mechanical switches, but more importantly, the top-out noise as well. The latter occurs when you release a key and there's often a loud tap as the key returns upwards, significantly adding to the noise made by the switch during a keystroke. While you can use O-rings to reduce bottom-out, there's nothing you can do to alleviate top-out.

The effect is quite profound. The switches, in our case, the silenced Cherry MX Red variety, were noticeably quieter than standard switches, with the top-out especially being much quieter, although they're still louder than membrane and scissor switches. The actuation force (45cN for a Red switch) and general feedback is identical to the vanilla Red switches too, although they feel slightly different and clearly have reduced audible feedback too. As such, you might not take to them instantly, even if your current keyboard uses Red switches.

There are some other good features too. As usual, Corsair's Utility Engine allows complete control over key assignments and backlighting, and while it appears complicated to new users, you can find your way around quite quickly. You can also record macros, or assign keys to execute macros, Windows shortcuts or media controls. Meanwhile, the per-key RGB backlighting control is superb, and the lighting itself is much more pleasant and flexible than that on the original Strafe too.

Conclusion

The silent Cherry MX switches really do offer much quieter but the Strafe RGB itself sports numerous other features that may well tempt you to pay a little more over the standard Strafe.

It's also cheaper than many other RGB keyboards, although the plastic construction and lack of dedicated media and macro controls mean it doesn't quite offer an overall package that stands out as being worthy of an award.

ANTONY LEATHER

/SPECIFICATIONS

Connection Wired, USB
Cable 2m, non-braided
Material Plastic
Switch type CherryMX Silent
Backlighting RGB
Extras USB pass-through, wrist rest, additional textured keys

DESIGN 35/40
FEATURES 31/30
VALUE 19/30
OVERALL SCORE 85%

VERDICT

The silent Cherry switches are noticeably quieter than standard switches and there's plenty more to like too. It's just a shame Corsair has omitted some of the popular features from its previous keyboards.

ATX MOTHERBOARD

Asus Sabertooth Z170 / £195 inc VAT

SUPPLIER www.ebuyer.com

With a price that's close to £200 inc VAT, there are certainly cheaper options than Asus' Sabertooth Z170 TUF board if you're looking to jump on the Skylake bandwagon. However, few boards offer anywhere near its number of features.

Let's start with Asus' Thermal Armor, which the company claims improves cooling by directing airflow from a couple of tiny included fans onto the PCB. We've always been in two minds about the Thermal Armor – you need to use the fans to keep your system cool and they can sound whiny – if you don't use the fans, a huge area of the PCB is essentially blocked off from your case's airflow. Also, it can get in the way. For instance, the top left-hand corner of the CPU socket area is very cramped and installing coolers is tricky as a result. Oddly, there are also vents that can be opened and closed, although it's unclear why you'd want them closed.

You can easily remove the Thermal Armor to spray-paint it

However, the Thermal Armor does have a plus side – it looks fantastic. If you're into modding, you can easily remove it to spray-paint it to match your case or other hardware. Asus has also included a complete set of blanking covers for the PCI-E slots, DIMM slots and rear I/O ports. These covers are meant to keep out dust but, when combined with the Thermal Armor, they give it a decidedly stealth bomber-like look. The rear of the motherboard sports a large steel plate too, which Asus claims prevents the PCB from bowing under stress and also aids cooling.

The accessories list doesn't stop there, though, as Asus has included a PCI-E-to-M.2 adaptor, which can house up to 110mm SSDs, in addition to the 110mm-long slot on the motherboard itself. The latter, though, is sealed in a small chamber in the Thermal Armor and while we didn't see any speed drop-offs during testing, our SSD did get a tad warm in that location. As such, it's good that there's another way of mounting an M.2 SSD. There are two SATA Express ports and eight SATA 6Gbps ports too, although two of the latter come courtesy of an ASMedia controller, so make sure any SSDs are hooked up to the faster Intel-controlled ports instead.

Meanwhile, the rear I/O panel is bristling with ports, including a pair of Intel Gigabit Ethernet ports, plus both USB 3.1 Type-A and reversible Type-C ports too. There's a notable lack of overclocking and testing tools here and on the PCB though – there are no buttons or LED displays, and just a jumper for resetting the CMOS. These features have always been missing from TUF motherboards, and it's a shame.

Layout is otherwise generally good. You get three 16x PCI-E slots and three 1x PCI-E slots, and one of the latter sits above the top 16x slot, so you'll be able to use a discrete sound card or the included M.2 adaptor no matter how many graphics cards you use. The first two 16x slots are also double-spaced, so air-cooled cards won't be cramped.

The main feature of TUF motherboards that justifies their price, however, is the software and fan control. There are six 4-pin fan headers on the PCB and all of them can be automatically controlled using the included Thermal Radar 2 software. This suite enables you to tweak each of the fan profile curves and even switch off fans below certain CPU temperatures if you're just browsing the Web. You can also set each fan to provide post-shutdown cooling. The headers work with 4-pin or 3-pin fans too – the latter's fan speed can be adjusted and not just fixed. You can also reduce the speed of the small chipset fans to reduce the aforementioned whiny sound.

In addition, the Sabertooth Z170 also has three thermal sensors that you can connect to headers on the motherboard, so you can monitor the temperatures of your other hardware or even coolant using a thermal probe. In short, it's a tweaker's dream.

/SPECIFICATIONS

Chipset Intel Z170

CPU socket Intel LGA1151

Memory support 4 slots: max 64GB DDR3 (up to 3733MHz)

Expansion slots Three 16x PCI-E 3, three 1x PCI-E 3

Sound Realtek ALC1150

Networking Two Intel Gigabit LAN

Overclocking Base clock 40–650MHz, CPU multiplier 8–83x; max voltages, CPU 1.7V, RAM 2V

Ports 6 x SATA 6Gbps (Z170), 2 x SATA 6Gbps (ASMedia), 2 x SATA Express, 2 x M.2, 6 x USB 3, 5 x USB 3.1 Type-A, 1 x USB 3.1 Type-C, 5 x USB 2, 2 x LAN, 3 x surround audio out, line in, mic, 1 x HDMI 1.4, 1 x DisplayPort 1.2

Dimensions (mm) 305 x 244

1 **The top two 16x PCI-E slots are double-spaced, for dual-slot cards**

2 **There are two SATA Express ports and eight SATA 6Gbps ports on the edge**

3 **The Thermal Armor looks great, but the two tiny fans can sound whiny**

Performance

At stock speed, the Sabertooth Z180's system score of 129,358 in our RealBench 2015 suite wasn't exceptional, sitting behind MSI's Z170A Xpower Gaming TE and Asus' Maximus VIII Ranger. On the plus side, the audio performance of -104.3dBA and 104.2dBA for noise and dynamic range respectively in RightMark was typical of Asus' Z170 line-up, with only the Maximus VIII Impact offering superior sound. Storage performance was right on the money too.

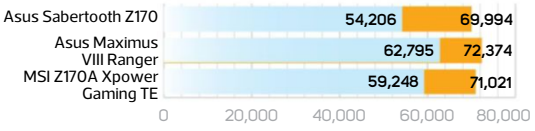
Thankfully, the Sabertooth Z170 is a great overclocker. Using its excellent, easy-to-use EFI, we pushed our Core i7-6700K up to 4.8GHz with a 1.34V vcore, and its system score of 151,774 was then much more competitive too. Power consumption was the Sabertooth Z170's trump card, though, with our system drawing just 56W when overclocked at idle, and peaking at 180W under load.

Conclusion

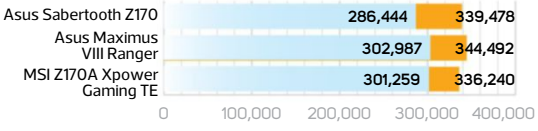
The Sabertooth Z170 is a pricey Skylake board, but the extra features (and extended warranty) will definitely appeal to anyone that likes tinkering with their PC. There are a few issues to be aware of, such as the noisy chipset fans, slightly cramped CPU socket area and mediocre stock-speed performance, but on the whole it's a good-looking, well-featured motherboard that justifies its asking price.

ANTONY LEATHER

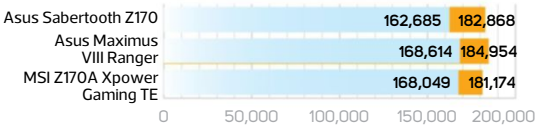
GIMP IMAGE EDITING



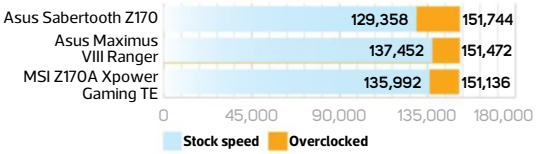
HANDBRAKE H.264 VIDEO ENCODING



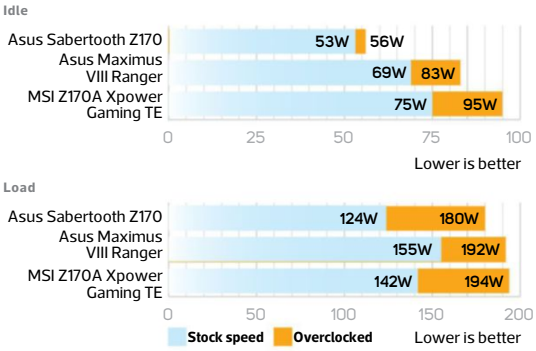
HEAVY MULTI-TASKING



SYSTEM SCORE

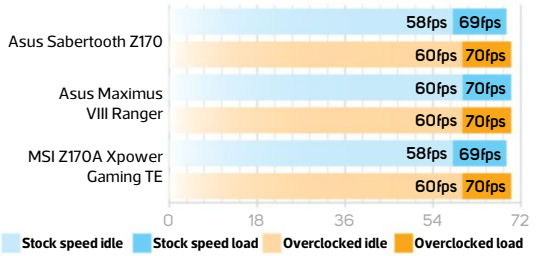


TOTAL SYSTEM POWER CONSUMPTION



TOTAL WAR: ATTILA

1,920 x 1,080, 0x AA, Quality setting



SPEED 34/40 | FEATURES 25/30

VALUE 25/30

OVERALL SCORE 84%

VERDICT

Feature-packed, good-looking and bursting with tweakable features and accessories, although you pay a premium for the privilege.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX 2666MHz DDR4 memory, 256GB OCZ Arc 100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

MINI-ITX MOTHERBOARD

MSI Z170i Gaming Pro AC / £130 inc VAT

SUPPLIER www.box.co.uk

Mini-ITX is becoming a big hit in enthusiast circles, with every major motherboard manufacturer looking set to offer at least one dinky motherboard that can take advantage of Intel's K-series Skylake CPUs. Last time, MSI was at the forefront of the small form factor battleground and its Z97 offering was easily a match for Asus and Gigabyte's equivalents. Sadly, there's still no competitor for Asus' top-end Impact, but with the new Z170i Gaming Pro AC, MSI is definitely looking to win some mid-range ground.

Its main competitor is Asus' Z170i Pro Gaming, which picked up an Approved award (see Issue 147, p26), thanks to a competitive price, great layout and plenty of features. The MSI Z170i Gaming Pro AC retails for the same price as the Asus board so, at face value, it could be a close call between them. Indeed, the layout is all but identical, with the SATA 6Gbps and SATA Express connectors, USB 3 header and 24-pin ATX connector all in the same place on both boards.

Wi-Fi is top-notch, with an Intel 8260 dual-band module and two antennae

The Asus board manages to squeeze in a total of three fan headers, though, whereas the Z170i Gaming Pro AC only has two – a shame, as MSI's motherboard also has a good fan control suite in the EFI. In terms of aesthetics, the Asus board also has the edge, largely thanks to the exposed Wi-Fi module that MSI has used, compared with the custom riser module that Asus employed. The Asus also has an extra heatsink cooling the power circuitry, as well as a USB 3.1 Type-A port whereas the Z170i Gaming Pro AC lacks USB 3.1 entirely.

Both boards lack any on-board overclocking or testing tools with the exception of the MSI, which has a rear-mounted clear-CMOS switch. They also employ rear-mounted M.2 ports, although the Asus Z170i Pro Gaming has a better trump card here. It can support up to 80mm SSDs, whereas the MSI board is limited to 60mm drives. That's quite a major drawback if you're planning an upgrade to a Skylake-based system to take advantage of the latest super-fast M.2 SSDs, such as Samsung's 80mm-long 950 Pro. It might be possible to use a piece of double-sided neoprene to attach a large SSD, as it's only the lack of a mounting point that prevents you installing a longer card. However, you may as well get the Asus board and save the hassle.

Thankfully, that's where our criticisms of the Z170i Gaming Pro AC's features end. The Wi-Fi is top-notch, with an Intel 8260 dual-band module and two antennae included in the box. Audio has been a focus for MSI too, with the Z170i Gaming Pro AC including a headphone amplifier, an isolated audio PCB with separate layers plus a dedicated USB port for USB DACs, which MSI claims offers a stable 5V supply for better performance.

MSI offers some familiar software features as well, such as RAMdisk and Hotkey, which are essentially very similar to the features that Asus includes with its ROG motherboards.

Performance

At stock speed, the Z170i Gaming Pro AC was behind the competition, with its image editing, multi-tasking and overall scores some way behind the rest of the field. For example, in the image editing test, it managed a score of 50,384 while the Z170i Pro Gaming mustered 53,492 and the Maximus VIII Impact 55,082. Overall, it managed a score of 127,426, while the Z170i Pro Gaming came in at 132,454. It was also behind Asus' competition in our game test, and the SATA 6Gbps speeds were a few megabytes a second off the pace too, although only by 1-2 per cent at most.

Meanwhile, overclocking the Z170i Gaming Pro AC was fairly painless thanks to its excellent EFI, which is up to MSI's usual clear, slick standards. However, we hit an issue where the clock speed would regularly clock down, leaving us unsure as to whether the overclock had been applied. After speaking to MSI, this issue turned out to be an overzealous cap on the default power limits, and manually raising them

/SPECIFICATIONS

Chipset Intel Z170
CPU socket Intel LGA1151
Memory support 2 slots: max 32GB DDR3 (up to 4200MHz)
Expansion slots One 16x PCI-E 3
Sound Realtek ALC1150
Networking Intel Gigabit LAN
Overclocking Base clock 98–341MHz, CPU multiplier 8–83x; max voltages, CPU 2.155V, RAM 2.2V
Ports 4 x SATA 6Gbps (Z170), 1 x SATA Express, 1 x M.2, 4 x USB 3, 3 x USB 2, 1 x LAN, 3 x surround audio out, line in, mic, 1 x HDMI, 1 x DisplayPort, 1 x PS/2
Dimensions (mm) 170 x 170

HOW WE TEST
PAGE 34

1 **The Intel 8260 dual-band 802.11ac Wi-Fi card connects to two included antennae**

2 **The 24-pin ATX socket and SATA Express port sit on the edge**

3 **There's a dedicated USB port for external DACs, but no USB 3.1 support**

solved the problem – MSI has also fixed this issue in the latest 1.3 BIOS.

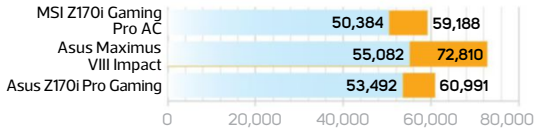
However, despite now staying put at higher frequencies, the best clock speed we could get out of the Z170i Gaming Pro AC was 4.6GHz, despite pushing the voltage above 1.4V and trying numerous voltage modes. As such, the MSI wasn't able to claw too much ground back from its disappointing start, with a system score of 144,164 compared to 147,915 for the Asus Z170i Pro Gaming. Thankfully, audio performance was right on the money and a match for the similarly priced Asus board.

Conclusion

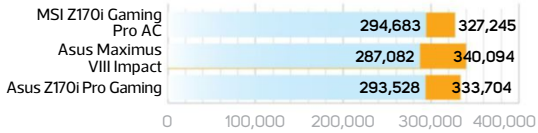
The MSI Z170i Gaming Pro AC is a solid effort that will disappoint few people, but the Asus Z170i Pro Gaming still outdoes it in numerous areas, including stock speed performance and overclocking, for the same price. The inability to use the latest 80mm M.2 SSDs is an oversight too, as is the lack of USB 3.1. The Z170i Gaming Pro AC isn't bad, but for this price, the Asus' competition is a better deal.

ANTONY LEATHER

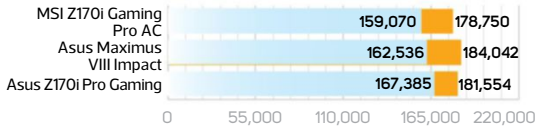
GIMP IMAGE EDITING



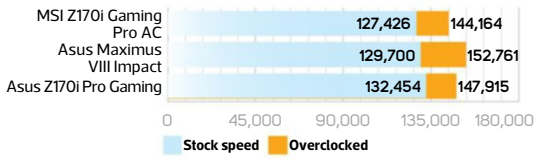
HANDBRAKE H.264 VIDEO ENCODING



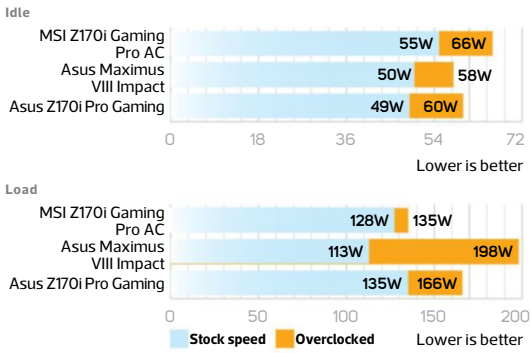
HEAVY MULTI-TASKING



SYSTEM SCORE

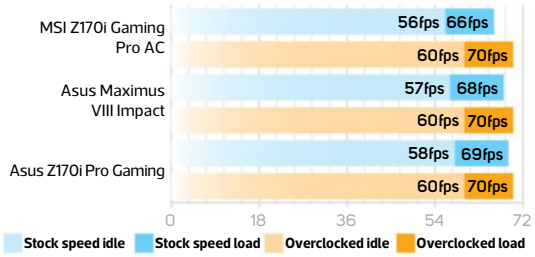


TOTAL SYSTEM POWER CONSUMPTION



TOTAL WAR: ATTILA

1,920 x 1,080, 0x AA, Quality setting



SPEED **34/40** | FEATURES **20/30**

VALUE **24/30**

OVERALL SCORE **78%**

VERDICT

A decent board, but it doesn't support 80mm M.2 SSDs, and Asus' Z170i Pro Gaming offers better overclocking and faster performance for the same money.

/TEST KIT

4GHz Intel Core i7-6700K, 16GB Corsair Vengeance LPX 2666MHz DDR4 memory, 256GB OCZ Arc 100 SSD, Corsair HX860i PSU, Windows 10 Home 64-bit

PC Specialist recommends Windows

Windows 10

Performance without compromise

Spectre Lite

- AMD FX-4300
- ASUS® M5A97 R2.0
- 8GB Hyper-X FURY RAM
- 2GB NVIDIA® GeForce® GTX 950
- 1TB Hard Drive
- Corsair 350W Power Supply
- **Windows 10**
- 3 Years Standard Warranty

THIS SPEC FROM **£499***

Gladius 900

- Intel® Core™ i5-6600k
- ASUS® Maximus VIII Hero
- 8GB HyperX FURY RAM
- 2GB NVIDIA® GeForce® GTX 960
- 1TB Hard Drive
- Corsair 450W Power Supply
- **Windows 8.1**
- 3 Years Standard Warranty

THIS SPEC FROM **£899***

Zephyr Elite

- Intel® Core™ i5-6600K
- ASUS® MAXIMUS VIII Hero
- 16GB HyperX FURY RAM
- 4GB NVIDIA® GeForce® GTX 980
- 120GB HyperX SAVAGE SSD
- 1TB Hard Drive
- **Windows 8.1**
- 3 Years Standard Warranty

THIS SPEC FROM **£1,399***

Delta Ultimate

- Intel® Core™ i7-6700K
- Gigabyte Z170XP-SLI
- 16GB HyperX FURY DDR4 RAM
- 6GB NVIDIA® GeForce™ GTX980Ti
- 480GB HyperX SAVAGE SSD
- 2TB Western Digital Black Hard Drive
- **Windows 10**
- 3 Years Standard Warranty

THIS SPEC FROM **£1,799***

Enigma VI

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- Intel® Integrated Graphics
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- Full HD IPS Screen
- Up to 7.5 Hours Battery
- Wireless as standard
- **Windows 10**
- 3 Years Standard Warranty

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Octane II

- 6th Gen Intel® Core™ CPUs
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4K GAMING MONITOR

Asus ROG Swift PG27AQ / £750 inc VAT

SUPPLIER www.scan.co.uk

Asus has one of the widest ranges of adaptive-sync displays on the market, catering for both G-Sync and FreeSync, for users of Nvidia and AMD GPUs respectively. Their general high quality has impressed us in previous reviews, and they've also come packed with features, including flexible stands that pivot, rotate and tilt, as well as great on-screen display software, controlled by a small joystick at the rear of the display. The ROG Swift PG27AQ breaks new ground, though, being a 27in G-Sync display with an IPS panel and a low 4ms response time.

As such, you can expect superior image quality and viewing angles compared with your average TN panel, but without the severe ghosting problems of some older IPS monitors. What's more, it has a native 4K resolution and supports G-Sync up to 60Hz. While it isn't the first IPS adaptive-sync display we've seen, or the first 4K monitor with G-Sync, it's the first screen we've seen that offers all three. While Acer's XB280HK 4K also features G-Sync, for example, that display has a TN panel rather than IPS.

The vast majority of alternative G-Sync screens also have a 2,560 x 1,440 native resolution, but can go up to 144Hz. This higher refresh rate isn't possible at 4K due to the required bandwidth, which exceeds the capability of DisplayPort 1.2. Faster panels will have to wait for a new DisplayPort standard, which will only be possible with new graphics cards as well.

Until now, all G-Sync displays have been limited to a single DisplayPort input, unlike FreeSync monitors. Asus has added a secondary HDMI port to the PG27AQ, though, meaning you can connect a games console to it, or a second PC, although it's only HDMI 1.4, so you won't be able to display 4K resolutions at 60Hz from it, or use G-Sync.

There are a few other omissions as well. Nvidia's 3D Vision technology has been cut, as has ULMB (ultra-low motion blur). There's also some artificial segmentation on the part of Asus. The PG27AQ is absolutely aimed at gamers, so it therefore offers plenty of features gamers might want, but a few other features that are generally quite common on cheaper displays have been deliberately removed. Multiple gamma settings is one example. The screen is set to 6,500K, and you can't change it.

It's easy to understand why. Gamers probably don't adjust the gamma much, and that feature might be better suited to a graphic designer or photographer. But what about photographers who also enjoy gaming? When spending this much on a display, it would be ideal to have as much picture control as possible, even if those features aren't going to be used by everyone.

ELITE
NEW ENTRY
P60

However, that isn't to say the OSD is light on features. It has six GameVisual image presets, as well as controls for colour temperature, saturation, brightness and contrast. There's also a crosshair to help you 'cheat' in FPS games and a useful on-screen fps counter. With G-Sync enabled, the display's frame rate is locked to your graphics card, so this readout is accurate, at least up to 60fps.

The OSD is a joy to use too. The joystick at the back offers a great way to quickly navigate through the menus, and Asus has put thought into where the settings have been placed. The most common ones have their own menus while the more specialist settings are found in a larger menu at the end, which makes sense.

In games and on the Windows desktop, the picture quality of the PG27AQ is excellent. We tested it with a Spyder 4 Colorimeter, and measured brightness of 297cd/m^2, roughly matching Asus' 300cd/m^2 claim. It isn't the brightest display, but you don't notice it at all in use. The panel quality is generally brilliant, with an out-of-the-box delta E under 1, a 550:1 contrast ratio, 100 per cent sRGB coverage and 80 per cent Adobe RGB coverage – a great result. What's more, the monitor performed negligibly better after full calibration, so the out-of-the-box performance is superb.

The brightness uniformity wasn't up to the standard of some displays for professional-level photography though. Our results showed deviation between 6-18 per cent, but that's not really important for a gaming monitor.

What matters is games performance, and the tear-free G-Sync effect when playing a few intense rounds of Battlefield 4 multiplayer made the PG27AQ superior to any 4K display without adaptive-sync tech. It might not be able to manage the 144Hz G-Sync gaming of lower-resolution screens, but with current technology and standards, the PG27AQ is as good as it gets for 4K adaptive-sync gaming.

Conclusion

Although it isn't perfect, the PG27AQ is the best 4K gaming display around, with a great picture, excellent OSD and G-Sync support. While it has an excellent panel, though, it isn't as useful for pro-graphics work as it is for gaming. The lack of a 144Hz refresh rate is also notable, but few people have a PC that can handle such frame rates at 4K with maximum detail anyway. In short, if you're looking to make the leap to 4K for gaming and have an Nvidia GPU setup, the Asus ROG Swift PG27AQ is as good as it gets.

ORESTIS BASTOUNIS

IMAGE	FEATURES	VALUE	OVERALL SCORE
49/55	14/15	21/30	83%

VERDICT

The absolute best 4K gaming monitor we've tested. It has a few limitations, but if you're looking for a G-Sync-friendly 4k monitor, the PG27AQ is as good as it gets.

GAMING CHAIR

Vertagear Racing Series S-Line SL4000 Gaming Chair / £215 inc VAT

SUPPLIER www.overclockers.co.uk

Vertagear is new to the growing gaming chair market. With so many people dedicating hours of their free time to sitting in one place while immersed in a game, comfort and posture become more than just an afterthought. Although any good-quality office chair is usually sufficient for comfort, a gaming chair offers a little more, with a look and feel that complements some gaming genres, such as racing and flight simulators. Vertagear's SL4000 sits in the middle of its range, with the SL5000 and SL2000 sitting on either side.

It isn't cheap, though, and at £215 inc VAT, it also omits some of the features of its competitors, such as built-in 2.1 speakers, so it's relying on looks and comfort alone. It has a very smart appearance, and what appears to be a good anti-RSI design, with adjustable seating and arm rests. The frame is made of solid steel and the entire chair is covered in PVC, with the seat filled with foam padding. It comes in five different colours too, with the red model reviewed here.

The chair comes with printed, diagram-based instructions that make assembly seem fairly simple. You get three main parts: the seat, the main backing frame and the base for the wheels, with the head support and arms being attached after these main parts are assembled. If you run into any problems, there are also online assembly video guides to follow.

The arms, back rest and head rest attached without a problem

It took just five minutes to fix the wheels to the seat. However, it then took another two hours to fix the backing section onto the seat's support struts, only after enlisting help from a second person. Getting the screws back into the holes, perfectly lined up, is a tough job for one person.

There are also silver guards around each hole that look like washers, but these guards fell off during assembly after only light pressure. In short, we expect better build quality from a £215 chair.

Once we got past that point, though, the arms, back rest and head rest attached without a problem. To maintain a healthy posture, a chair must be adjustable in all kinds of ways, and the SL4000 ticks nearly all the recommended boxes. The arm rests can be moved forwards and backwards, and turned 45 degrees left or right. It can be lowered and raised, or the seat angled backwards and forwards as well, by lifting a lever underneath. Meanwhile, the back rest can be moved up and down on its straps, while the head rest can also be moved by at least 10cm vertically. The arm rests can't be moved vertically though.

The back rest attaches to the chair by feeding plastic clips underneath the seat and through a hole at the top. If you find either the back rest or head rest uncomfortable, however, both of them can be removed. Meanwhile, the plastic arm rests feel slightly flimsy compared with the otherwise tough materials used in the rest of the chair.

The SL4000 measures 1,400mm high when fully raised, 1,280mm when lowered, and the seat is 370mm wide. Vertagear claims it can accommodate gamers with a weight of up to 150kg (23.6 stone) as well, so it will comfortably hold most people. It also has a two-year warranty.

After sitting in the chair for extended periods, the Vertagear SL4000 was very comfortable. The materials feel great and go a long way to justifying the steep asking price. The back rest works well and the head rest made for comfortable relaxing, especially with the seat moved back.

Conclusion

Although some aspects of the SL4100's build quality are questionable, and it's expensive, we soon forgot about these niggles after spending some time gaming in the Vertagear SL4000 for extended periods. It isn't easy to assemble, but it looks good, it's very comfortable and it offers plenty of adjustment for extra comfort.

ORESTIS BASTOUNIS

COMFORT	FEATURES	VALUE
45/50	18/25	16/25

OVERALL SCORE **79%**

VERDICT

Although it's let down by a few niggles, the SL4000 is a very comfortable gaming chair with lots of adjustment options.

HOW WE TEST
PAGE 34

CASE LIGHTING SYSTEM

NZXT HUE+ / £48 inc VAT

SUPPLIER www.scan.co.uk/ MODEL NUMBER AC-HUEPS-M1

If you're keen on lighting up your PC, you probably have a few sets of LED strips or cold cathodes in a drawer somewhere. The trouble is that as soon as you change PC cases or hardware, these lights invariably end up clashing with your new parts' colours. Similarly, standalone kits usually have limited lighting functions. However, NZXT reckons it has the answer with an update to its HUE programmable lighting system, called the HUE+.

The system consists of a 2-channel hub that can connect via a motherboard USB 2 header using an included cable, or externally using a standard micro-USB cable, and it's powered by a single Molex connector. Four 11cm LED strips are included; these can be daisy-chained into one continuous strip in single-channel mode, thanks to male and female connectors on either end, and they connect to the hub using 50cm proprietary connector cables – one for each channel port on the hub. What's more, the strips have self-adhesive pads for aluminium or plastic surfaces, but also sport built-in magnetic strips for clean and easy mounting to magnetic surfaces.

The strips have self-adhesive pads and built-in magnetic strips

There are also two 10cm, one 30cm and one 50cm extension cables, which can either sit between sets of LEDs strips to space them around corners, or they can simply provide further reach and help hide cables out of sight. Mounting the hub is easy; four screws are included that enable you to install it in a spare 2.5in bay, as long as the bottom mounting points are accessible, but it's light enough to mount with double-sided sticky pads or Velcro. Once powered, the hub emits a subtle white light but otherwise, it's very inconspicuous.

The key to the HUE+, however, is NZXT's CAM software suite, which gives you control over the lighting of both channels. Usefully, the LED strips are hot-swappable and detected in the software as soon as you connect them, which makes fitting them into your case in the right position a simple task. You can select from the usual fixed, breathing, marquee or RGB spectrum wave modes, or have each channel respond to CPU or GPU temperature, with colours for the latter configurable in 10°C steps between 20°C and 100°C. There's even the option to have them respond to your frame rate in games.

You can also set specific LEDs to certain colours and fiddle with the colour cycle in the preset modes. There's an audio mode too, although it's currently still in beta status, which may explain why it wasn't particularly responsive, even when thumping out some AC/DC. You can also set the lights to a single colour, including white, if you're not fussed about any of the effects. Most importantly, the LEDs are super-bright, and with four strips, it's easy to illuminate a large case.

/SPECIFICATIONS

Channels 2
Lighting RGB
Power Molex
LED strips Four 11cm strips, magnetic and self-adhesive

Conclusion

With 30cm LED strips retailing for between £5-10 each, including four of these strips as standard, along with several extension cables, this already means the HUE+ isn't bad value. However, the inclusion of a fully programmable hub and software suite with per-RGB LED tweaking all for under than £50 inc VAT is quite a feat.

It's a niche product, of course, and we'd make like to see more presets – it would be easy to implement a Knight Rider, for example. If you want to pimp out your pride and joy at the next LAN event, though, or simply want to own a single set of LED strips that you can colour-match to current and future systems, the HUE+ is exactly what you need.

ANTONY LEATHER

DESIGN 33/35 | FEATURES 32/35 | VALUE 29/30

OVERALL SCORE 94%

VERDICT

The HUE+ offers a near-perfect lighting kit with full RGB per-LED control and a good selection of preset effects, and it's bright enough to be effective in large PC cases.

ELITE NEW ENTRY P60

GAMING MOUSE

Cooler Master Xornet II / £20 inc VAT

SUPPLIER www.cclonline.com

There's a plethora of high-end gaming mice available featuring absurd resolutions, mind-boggling button and lighting customisation options, and wallet-busting price tags. The £20 Xornet II from Cooler Master, however, is a pleasant reminder that a quality mouse needn't cost a fortune.

At the heart of the Xornet II is the Avago 3320 sensor, a 3,500dpi optical model that's the upgrade to Avago's popular 3310 sensor. Of course, 3,500dpi doesn't sound like much these days, but it's still more than adequate for gaming and desktop use on a 1080p or 2,560 x 1,440 panel. More important than resolution is accuracy, and in this respect, the Xornet II is flawless, delivering smooth, one-to-one tracking free of acceleration, snapping or jitter across its range of resolutions.

Rubberised sections on both sides give your tips a good grip

This range starts at 250dpi and can be increased in 250dpi increments using Cooler Master's simple-to-use software suite. The mouse stores three resolutions on-board and the RGB scroll wheel can be set to a different colour for each one to act as a simple indicator. You can also configure the polling rate (maximum 1,000Hz) and lift-off distance, although tweaking the latter made no difference to our experience.

A great sensor is no good if the mouse is uncomfortable to wield, but thankfully, the opposite is true. If you're a claw-grip gamer, the Xornet II could hardly be better designed. It's a little on the small side, but rubberised sections on both sides give your tips a good grip and reliable control, while grooves for your other fingers ensure comfort even during extended play.

The Xornet II is light at 80g and this weight can't be adjusted, but this weight actually suits a claw grip well and the body is still solid. The two main buttons are isolated and have a smooth soft-touch finish, while it's comfortable to rest your hand against the matt surface elsewhere. The PTFE feet are also massive and thick enough to prevent drag on softer surfaces, while the USB cable is thin, flexible and attached via a strain reliever.

Omron switches are a staple of high-end mice but their inclusion in the £20 Xornet II is impressive – both main buttons feature D2FC-7-7N switches, which have excellent feedback and a light action that suits a wide variety of game types.

There's also a pair of thumb buttons, and two resolution-adjustment buttons sit south of the scroll wheel. Each of these buttons is raised slightly and positioned in a way that makes them easy to hit. They're a touch wobbly in their sockets, hinting at the low price tag, but it' a minor niggle and not distracting in use. That just leaves the scroll wheel, for which we're full of praise – it's seated securely, has a pleasant, rubberised surface with clearly defined notches when you scroll, and it has a well-tuned click force too.

Cooler Master has even managed to give its new mouse some basic button customisations for all seven switches, and the software is again delightfully simple to use. You can't have custom macros or multiple profiles, but basic key bindings and Windows functions can be applied with ease and are stored on the mouse itself. Added complexity is going to cost you more, but it's great to see some simple tweaks present in such an inexpensive mouse.

Conclusion

The Xornet II is a wonderful mouse, and it's refreshing to see the value it offers. Its shape is unlikely to appeal to palm-grip users, or gamers with larger hands, but it's ideal for claw-grip gamers. It even features excellent tracking, seven customisable buttons and on-the-fly resolution adjustment, but doesn't include superfluous tickbox features that needlessly bump up the price, making it very easy to recommend.

MATTHEW LAMBERT

/SPECIFICATIONS

Connection Wired, USB
Sensor Optical
Resolution 3,500dpi
Cable Rubber
Material Plastic
Extras None

DESIGN	FEATURES	VALUE
38/40	23/35	25/25

OVERALL SCORE **86%**

VERDICT

If you're a claw-grip gamer that values comfort and usability over fancy but needless extras, the Xornet II is the mouse for you.

Custom Kit

Paul Goodhead checks out the latest gadgets, gizmos and geek toys

POWER BANK

PulsePak Emergency Charger / £13 inc VAT

Measuring barely larger than a pair of AA batteries and tipping the scales at a mere 20g, the PulsePak is one of the tiniest external batteries we've seen. Cosseted away inside the tough plastic shell is a 500mAh cell – that's enough, PulsePak claims, to provide a two-hour charge to a modern smartphone.

That charge is hardly going to make a dent in a weekend at a festival, but in an emergency, an extra two hours of talk or screen time could be a life-saver. In testing, the PulsePak delivered too, adding an extra hour and 45 minutes of browsing time to a Nexus 6, albeit with the screen brightness turned down. The fragile connector can also be retracted back into the case, preventing it from getting bashed. At £13, it's an ideal stocking filler for anyone prone to running their phone battery down to 0%.

●●●●●

SUPPLIER www.firebox.com

BLUETOOTH SPEAKER

Gear4 Streetparty Wireless 3 / £40 inc VAT

If you were actually planning to host a street party with the Wireless 3, you'd be disappointed. Audio gets audibly crackly towards the top end of the volume scale, and the whole mix suffers from a lack of detail and crispness that robbed our test tracks of their punch and vibrancy.

It all feels like a missed opportunity, as the physical package of the speaker is well proportioned, feels well made and the soft touch plastic shell makes it pleasant to hold and handle. NFC pairing is a neat touch too (especially at this price) but ultimately, it's the audio quality that matters and we've heard better audio from smaller speakers such as the similarly priced Voombox Ongo.

●●○○○

SUPPLIER www.currys.co.uk

TOY

Sphero BB-8 / £130 inc VAT

Given that Sphero specialises in remote controlled spherical toys, it isn't surprising to see a BB-8 branded model this Christmas. Mechanically, it's phenomenally impressive. It runs about like nobody's business, with the head module scampering about on top trying to stay central, just like in the film. The squeaks and squawks it emits are rather cute too.

As with previous Sphero iterations, though, controlling BB-8 via the free smartphone or tablet app is a skill that's beyond us. It's tricky just to tell which way it's facing. This makes playing with the droid feel like hard work, although there are basic voice commands you can use instead. Beyond that, there's little else to do other than run around until the battery dies. It's technically very impressive, but you don't get much in the way of long-term fun for your £130.

●●●○○

SUPPLIER www.firebox.com

Seen something worthy of appearing in Custom Kit? Send your suggestions to paul_goodhead@dennis.co.uk

MINCE PIE Megatest

We've been tasting mince pies for nearly a decade now on **Custom PC**, so we know a thing or two about what goes into a good festive snack. This year is no different, with 16 pies on test. All pies were tasted blind by our expert panel of six judges, whose scores were summed, before a price-based weighting was applied

Pie tasters: Antony Leather, Ben Hardwidge, Iain Bristow, Matthew Lambert, Orestis Bastounis and Paul Goodhead
Words: Paul Goodhead

Selfridges Speciality / £7.99 for four

At £2 per pie, these handmade-looking treats aren't cheap, but their crunchy, shortbread-like pastry and sticky, moist filling drew murmurs of appreciation from the judges, as did the balance between pastry and filling. The price is too high, but they're decent pies if you have posh visitors.

SUPPLIER www.selfridges.com

M&S Classic Recipe / £1.80 for six

M&S has a proud pedigree in this test, but it won't continue if this pie is its idea of classic. Over-sweetened mincemeat and additional granulated sugar on top led to a sickly-sweet mouthful that we found unbalanced, with insubstantial, soft pastry adding insult to injury. It's not offensively bad, but it definitely isn't a classic.

SUPPLIER www.marksandspencer.com

Co-op Truly Irresistible / £2 for six

We haven't tried the Co-op's pies before but clearly we've been missing out. The thick and crunchy pastry was a treat, but it was the flavour and lingering taste of the generous, rich, spicy and currant-filled mincemeat that stole the show. The pastry could have a touch more butter, but it's otherwise a fine pie.

SUPPLIER www.co-operativefood.co.uk

Tesco Finest / £2 for six

The snowflake patterns on top of these Tesco Finest pies are pretty, and while cutting into them revealed Tesco being 'economical' with the filling, what was there was good. It had a pleasant tang and a distinct orange peel note to it. The pastry, however, let the side down by being bland and largely forgettable.

SUPPLIER www.tesco.com

Hoppers / 64p for six

Costing under 11p per pie, these Hoppers pies were the cheapest festive snacks on test and it's easy to see why; they're absurdly thin. They look like mince pie road kill, and there's only a meagre amount of paste-like filling inside as well. The flavour was inoffensive, however, which is more than we can say for some pies on test this month.

SUPPLIER www.morrisons.com

M&S Gluten Free / £2.50 for four

It's noble to cater those with coeliac disease, but sadly you can't build a quality pie on goodwill alone. The pastry was dusty and disintegrated unpleasantly as soon as we bit into it, leaving our mouths dry and swamping the mediocre filling. At 63p per pie, they're expensive too. Leave these pies on the shelf unless you've no other choice.

SUPPLIER www.marksandspencer.com

Mr Kipling / £1.40 for six

The tartness of the mincemeat encased in these pies initially took most of the judges by surprise, but once the shock had ebbed, most agreed it was actually quite pleasant. More divisive, however, was the lingering aftertaste – some found it pleasant, while others found it odd and artificial. Either way, there are better pies available.

SUPPLIER www.sainsburys.co.uk

Waitrose Christmas Tree Puff / £3 for six

Pastry or pie? The box says pie, so it's fair game for this test, but the argument is moot, as they aren't great anyway. Most judges questioned whether they were out of date (they weren't) and agreed that the pastry swamped the filling. There was a pleasant almond aftertaste, but that wasn't enough to save them.

SUPPLIER www.waitrose.com

Duchy Originals from Waitrose / £4 for six

Despite a slight rebranding, the Duchy Originals still retain the ingredients that made them our 2014 champion pie. Crunchy, distinctly buttery pastry coddled a generous portion of sticky filling that was rich and spicy, and full of juicy fruit chunks. They're a touch on the pricey side, but you'll forget that as soon as you bite into one.

SUPPLIER www.waitrose.com

Aldi Specially Selected / £1.15 for six

We wish we could say that these pies are forgettable, but the acrid notes evident in the mincemeat contained will stay with us for a long time. 'Bleach' and 'PVA glue' were two tasting notes recorded in between the spluttering, complaining and swearing. Don't be tempted by the cheap price.

SUPPLIER www.aldi.co.uk

Waitrose All Butter / £2.50 for six

Thick crunchy pastry with a pleasing snap instantly marked out this pie as a contender, but the filling is a bit of a curveball. It was noticeably light on currants and raisins, instead favouring candied orange and lemon peel with a marmaladey aftertaste. It isn't unpleasant, but it's not quite what you expect either.

SUPPLIER www.waitrose.com

Morrisons Signature / £1.74 for six

Generally, we find that manufacturers find it harder to get the pastry right than the filling. These Signature pies are a case in point – there's good, fruity filling (with lots of tasty cherry chunks in it), but it's let down by dry, fragile pastry that falls to pieces as soon as you take a bite. Underwhelming.

SUPPLIER www.morrisons.co.uk

Fortnum & Mason Traditional Recipe / £13.95 for six

Despite costing £2.33 per pie, these pies still missed the mark. Built tall like a cupcake, the pastry was soft and almost cake-like, which feels odd in your mouth. It tasted very good, as did the moist filling that had a deep, faintly chocolatey flavour. Even so, we'd rather have three packs of the Waitrose Duchy Originals for this money.

SUPPLIER www.fortnumandmason.com

LIDL Favorina / £1.49 for 12

LIDL rang the changes this year. Gone is last year's Snowy Lodge brand, replaced with Favorina. It made a slight difference too; the filling was pleasantly sweet and surprisingly generous for such a small pie, although the pastry was still mediocre. At £1.49 for 12, they're cheap too, if not that exciting.

SUPPLIER www.lidl.co.uk

Asda Extra Special / £1.25 for six

Asda's Extra Special pies are the best-value pies on test. The price of just 21p per pie nets you a chunky filling that's full of juicy currants and strikes the right balance between sweet and spicy. The pastry is fine if not spectacular, but the overall effect is well balanced and perfectly pleasant.

SUPPLIER www.asda.com

Sainsbury's Taste the Difference / £2.50 for four

These bumper-sized pies looked like the real deal, and the crunchy, richly buttery pastry backed up that initial impression. Unfortunately, our judges felt that the filling, despite having a noticeable boozy hit, wasn't as satisfyingly tasty as the filling in the Co-op or Waitrose Duchy pies.

SUPPLIER www.sainsburys.co.uk

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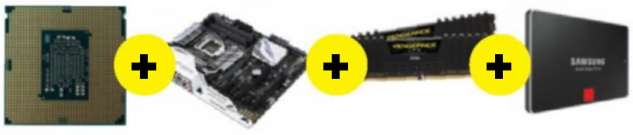
How we test

Thorough testing and research is the key to evaluating whether a product is worth buying, and deciding whether or not there's a better alternative

PROCESSORS

We judge CPUs on whether they offer sufficient speed for the price. Part of a CPU's speed score comes from how overclockable it is. Every type of CPU is tested in the same PC, so all results are directly comparable.

INTEL LGA1151



Intel LGA1151 CPU | Asus Z170 Deluxe | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 256GB Samsung 850 Pro

INTEL LGA2011-V3

Intel LGA2011-v3 CPU | Asus Rampage V Extreme | 16GB Corsair Vengeance LPX 2133MHz DDR4 | 512GB Crucial MX100

AMD FM2+

AMD FM2+ APU | MSI A88X-G45Gaming | 16GB Corsair Vengeance Pro 2133MHz DDR3 (GPU testing) | 8GB Corsair Vengeance Pro 1600MHz DDR3 (CPU testing) | 240GB Crucial M500

COMMON COMPONENTS

Nvidia GeForce GTX 780 3GB | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015, Cinebench R11.5 and a variety of games. We also test the power draw of the test PC with the CPU installed. These tests reveal a broad range of performance characteristics, from image editing to gaming and video encoding to 3D rendering. We run all tests at stock speed and again when overclocked to its highest frequency.

*Please note: We test AMD FM2+ APUs using the on-board graphics, not the Nvidia GeForce GTX 780 3GB

GRAPHICS CARDS

Graphics cards are mainly evaluated on how fast they are for their price. However, we also consider the efficacy and quietness of the cooler. Every graphics card is tested in the same PC, so all results are directly comparable.

4.2GHz Intel Core i5-3570K | 8GB Corsair Dominator 2400MHz DDR3 | Asus Maximus V Extreme | Windows 10 64-bit | The graphics card we're reviewing

CUSTOM PC REALBENCH 2015

INTEL REFERENCE

Intel Core i7-4790K | 16GB of Corsair 2400MHz DDR3 | 240GB OCZ 150 | Asus Maximus Gene VII | Nvidia GeForce GTX 780 3GB = 100%

AMD REFERENCE

AMD A10-7850K | 8GB of Corsair 2133MHz DDR3 | 256GB Plextor M5 Pro | Asus A88X-Pro = 100%

Our benchmark suite, co-developed with Asus, simulates how people really use PCs – a higher score is better. You can download them from www.asus.com/campaign/Realbench

MOTHERBOARDS

Motherboards are evaluated on everything from layout and features to overclockability and value for money. Every motherboard is tested with the same components, so all results are directly comparable.

INTEL LGA1151

Intel Core i7-6700K | Motherboard on test | 16GB Corsair Vengeance LPX 2666MHz DDR4 | 240GB OCZ Arc 100

AMD FM2+

AMD A10-7870K | Motherboard on test | 16GB Corsair Vengeance Pro 2133MHz DDR3

INTEL LGA2011-V3

Intel Core i7-5960X | Motherboard on test | Plextor M6 256GB | 32GB Crucial 2133MHz DDR4

COMMON COMPONENTS

AMD Radeon R9 390X* | Windows 10 64-bit

TESTS: We use Custom PC RealBench 2015 andTotal War: Attila, and also test the speeds of the board's SATA and M.2 ports. We try to overclock every motherboard we review by testing for a maximum QPI, base clock or HTT as well as overclocking the CPU to its maximum air-cooled level. We run our tests at stock speed and with the CPU overclocked.

*Please note: We test AMD FM2+ motherboards using the on-board graphics, not the AMD Radeon R9 390X

TESTS: By using the fast PC detailed on the left, we can be sure that any limitations are due to the graphics card on test, rather than being CPU limited. We test GTA V, Shadow of Mordor, Crysis 3, Alien: Isolation and The Witcher III: Wild Hunt at their maximum detail settings, in their highest DirectX mode, at several resolutions. High-end cards should be able to sustain playable frame rates at 2,560 x 1,440, while 1,920 x 1,080 is more important for mid-range cards; we also test at 3,840 x 2,160 for 4K monitors, and try to overclock every graphics card we test to assess the performance impact.

The Awards

EXTREME ULTRA
Some products are gloriously over the top. These items of excellent overkill earn our Extreme Ultra award.

PREMIUM GRADE
Premium Grade products are utterly desirable – we'd eat nothing but beans until we could afford them.

PROFESSIONAL
Products worthy of the Professional award make you and your business appear even more awesome.

APPROVED
Approved products are those that do a great job for the money; they're the canny purchase for a great PC.

CUSTOM KIT
For those gadgets and gizmos that really impress us, or that we can't live without, there's the Custom Kit award.

NAND of hope and glory

We test loads of next-gen SSD tech, from M.2 drives to PCI-E cards, to find the best solid state partners for a modern system

When Intel launched the Z97 chipset, motherboards started to feature a new type of connector called M.2. Its main use so far has been for SSDs, with one of the main advantages being its ability to carry data across either the SATA or PCI-E bus, with the latter offering the potential for much faster transfer speeds than you get from a standard 2.5in SATA SSD.

M.2 storage devices are much smaller, squeezing the NAND flash, controller and memory cache onto a stick that measures 22mm wide and (usually) 80mm long. The connector delivers both power and data, and needs no extra cabling, enabling you to fit a whole PC into even smaller cases, or entirely remove the drive caging from your chassis, giving you extra room for water-cooling kit, or whatever takes your fancy.

There's more to M.2 though. Along with this new form factor, a new bus protocol called NVMe has been designed to replace AHCI, a standard introduced over ten years ago for connecting storage devices to a PC. It supports much longer command queues, and reduces overheads for superior transfer speeds and lower latency. At this early stage, M.2 complements rather than replaces traditional SATA ports, but it also co-exists with PCI-E add-in cards, which can offer the same faster speeds.

These new standards, connectors and device sizes have made PC storage more interesting, but also a little confusing. As such, over the next few pages, we'll not only review several M.2 and PCI-E SSDs, but also explain how M.2 works and the differences between drives.

MATTHEW LAMBERT AND ORESTIS BASTOUNIS

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Plextor M6e Black Edition / p46
Samsung SSD 850 Evo M.2 / p47
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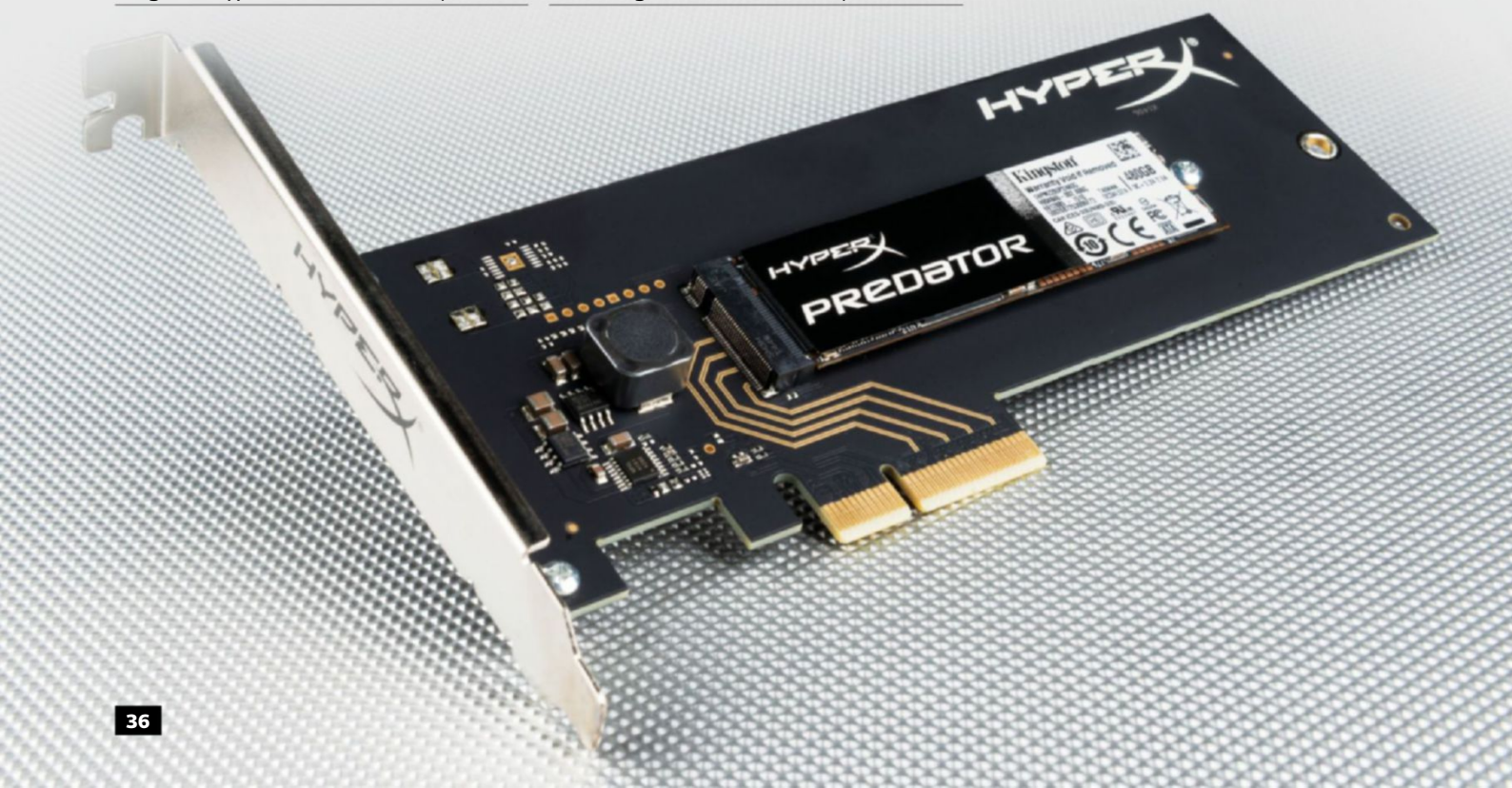
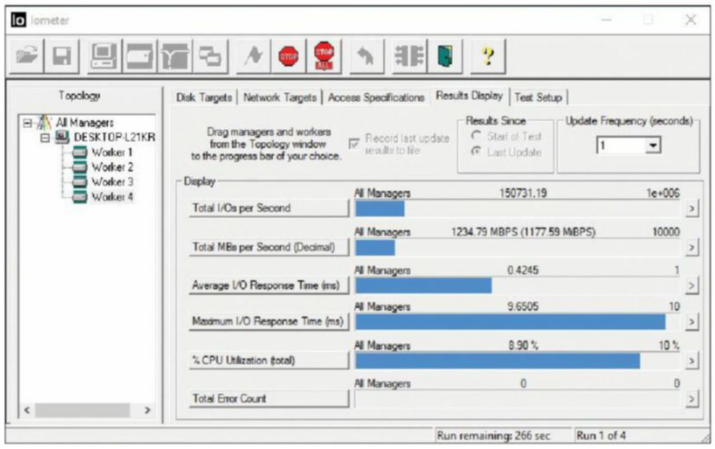
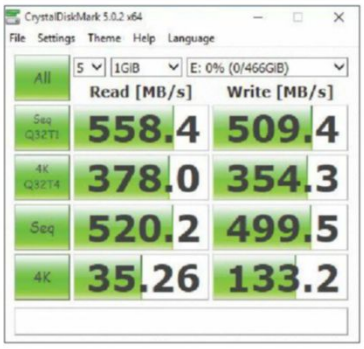


How we test





Our SSD test suite includes Iometer, CrystalDiskMark and BootRacer

There are many facets of SSD performance that can be assessed. Our own battery of tests comprises synthetic benchmarks, trace-based storage workloads in PCMark 7 and PCMark 8, boot time measurements and Iometer's I/O workload generator. Prior to testing, we issue an ATA Secure Erase command to each drive using the SSD's software package if available, or with the Parted Magic (**www.partedmagic.com**) Linux build if not. This procedure erases all data and resets the SSD to factory performance.

We first run the synthetic benchmark CrystalDiskMark 5.0.2 to give us a quick overview of a drive's peak sequential and random performance, at queue depths of one and 32 – the former is the most relevant to regular users, but the latter pushes most drives to their true peak performance. You can easily run the benchmark yourself to compare your own PC's storage performance against the drives on test. We use the default settings, but set the 32-queue-depth random test to use four CPU threads to maximise the load on NVMe drives. Each test is automatically run five times, and we report the average.

For real-world testing, we first use PC Mark 7's Secondary Storage benchmark, which loops three times and averages itself. It uses recorded SATA traces (the exact traffic over the SATA bus at the time of recording) to simulate performance in seven different ways, including Windows programs, adding pictures and music, video editing and gaming. It then generates an overall score based on the time taken to complete the tests. Next up is PCMark 8, which again uses traces, but with more modern programs. We've selected the Photoshop Heavy, Battlefield 3 and Microsoft Word tests, with the results this time being the time taken to complete the trace. All PCMark results include idle disk activity time, just as you would see in real-world use.

Next, we move to Iometer. We generate four 64-queue-depth, four-threaded workload patterns (database, file server, workstation and web server) designed to simulate extremely heavy sustained use scenarios with different file sizes and write-to-read ratios. We run each test one after the other for five minutes, each using fully random data – easily enough to stress a modern SSD controller. The number reported is the average IOPS (input/output operations per second) of all four tests.

The last test times how long it takes to boot a clean Windows 10 64-bit installation using the freely available BootRacer, which measures boot times down to a thousandth of a second. We install the chipset, graphics, USB and audio drivers and reboot the system five times to allow Windows to get its caching in order. We then take an average of five cold boot times, which involve restarting the system and a full reloading of the operating system with all necessary drivers and services. Next, we take an average of five fast startups, which is the default behaviour following a shutdown (different to resuming from standby). Here, Windows has saved the kernel and loaded drivers into the hibernation file (hiberfil.sys), which it then loads back into system memory when you boot up – for this part, only the loading of the desktop environment is timed.

All tests are performed on an MSI X99A Godlike Gaming motherboard using an Intel Core i7-5960X and 16GB of G.Skill RipjawsV DDR4 RAM. All CPU power-saving features are disabled.

THE SCORES

The speed score is taken from a weighted breakdown of the performance tests. CrystalDiskMark accounts for 20 per cent of this score (with a heavier weighting on low-queue-depth results), while 70 per cent of it is allocated to the PCMark 7, PCMark 8 and BootRacer real world tests, as they're the most relevant for everyday use. The final 10 per cent comes from Iometer, as the sustained high-queue depth workloads are only applicable to the most hardcore professional and workstation users. The pound per gigabyte (£/GB) score is then based on the pricing at the time of writing over the accessible formatted capacity, while the bang per buck score is essentially a ratio of the speed and £/GB metrics.

Crucial MX200 M.2

Crucial MX200 M.2 250GB / £76 inc VAT

SUPPLIER www.ebuyer.com

Crucial MX200 M.2 500GB / £128 inc VAT

SUPPLIER www.scan.co.uk

The 2.5in versions of Crucial's MX and BX SSDs have proved popular, with the BX100 occupying a well-deserved slot in our Elite list for its excellent value and bang per buck. There are some small differences between the MX and BX lines, of course. While both series are good choices for a price-conscious PC builder, the BX is the value option, with a relatively bare bones set of features, while the MX offers extras such as hardware encryption and a form of power-loss protection. With the M.2 variant, Crucial has taken the simple approach of squeezing the desktop 2.5in MX200 into an M.2 form factor, with the same controller and features.

It's a single-sided 2280 SATA drive with a Marvell 88SS9189 controller and 16nm 2-bit MLC NAND flash; not surprisingly, this is made by Micron, Crucial's parent company. The encryption and power-loss features carry over to the M.2 version as well. While the single-sided 80mm version is the drive on test, Crucial also sells 2260 double-sided variants, with the part name CT6997545, and there's also an mSATA version. Across all these form factors, 250GB and 500GB are the two capacities on offer.

Like its 2.5in siblings, the M.2 versions are very reasonably priced, with both the 250GB and 500GB drives being the cheapest drives on test. The 500GB version offers the best cost per gigabyte value we've seen from an M.2 drive, but whichever capacity you choose, there's only a small premium for opting for the M.2 version over the regular 2.5in SATA form factor, which is good to see.

Like the Samsung 850 Evo M.2 drives, an SLC cache plays a part with the MX200 M.2 drives; in Crucial's case, this is called Dynamic Write Acceleration. Unlike the fixed-size cache with Samsung's drive, with DWA the MX200 firmware grows and shrinks the cache as the free space on the drive changes. This feature was only present on the 250GB version of the 2.5in drive, but both capacities use it for the M.2 version.

Meanwhile, Crucial's SSD management software, called Storage Executive, isn't quite as polished or feature-packed as Samsung's offering, but it still offers a great visual UI and the usual functions such as firmware updates, secure erase and SMART information.

> The 500GB version offers the best cost per gigabyte we've seen from an M.2 drive

In our tests, with the exception of 32-queue-depth sequential read, the MX200 comes out marginally behind Samsung's 850 Evo, with both drives performing considerably better than the alternative SATA-based M.2 SSDs – the Transcend MTS800 M.2 and Kingston SSDNow M.2.

It's a trend that continues with the other tests. In (most of) the PCMark traces, the MX200 M.2 and 850 Evo M.2 are almost neck and neck, while in Iometer, the average IOPS from the MX200 drives is slightly in front, but again, both the MX200 and 850 Evo drives achieve considerably better results than the alternative SATA M.2 drives.

This combination of good performance and value for money translates to great bang per buck from the Crucial MX200 M.2. There isn't a huge difference between these drives or Samsung's 850 Evo drives, but both are clearly one step ahead of competing SATA-based M.2 SSDs.

Conclusion

The Crucial MX200 M.2 and Samsung's 850 Evo M.2 are so close that they're practically indistinguishable from each other, meaning that either series of drives will be well suited to a budget system. However, the Crucial's lower price just edges it into award territory. The 250GB MX200 M.2 is by far the cheapest M.2 SSD on the market, while the 500GB version has the best cost per gigabyte ratio we've seen. The MX200 series might not offer the fantastic speeds of the latest PCI-E and NVMe drives, but if you're looking to save space on drives and cabling, they offer well-performing SATA M.2 storage for a very reasonable price.

VERDICT

The cheapest M.2 drive series on test is also a great performer, making it our best budget M.2 buy.

CRUCIAL MX200 M.2 250GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
31/50	18/20	27/30	76%

CRUCIAL MX200 M.2 500GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
31/50	19/20	30/30	80%

Intel SSD 750 Series 1.2TB / £798 inc VAT

SUPPLIER www.scan.co.uk

Intel beat Samsung to market with a PCI-E 3 NVMe SSD in the form of the 750 Series. It comes in either a half-height, half-length add-in card format, or in a 2.5in case with an SFF 8639 (U.2) connector, rather than as an M.2 drive. Like Samsung's 950 Pro drives, it accesses four 1GB/sec PCI-E 3 lanes, so it offers far more bandwidth than PCI-E 2 devices such as the Plextor M6e M.2 and Kingston Hyper X Predator M.2.

Three capacities are offered, ranging from 400GB to 1.2TB. Unfortunately, Intel could only send us a 1.2TB sample for testing, which makes direct comparison between the drives on test slightly more complicated. We don't know exactly how the lower-capacity 750 drives will perform in our test suite, but they have the same number of dies per controller channel as the 1.2TB model, so performance is likely to be similar.

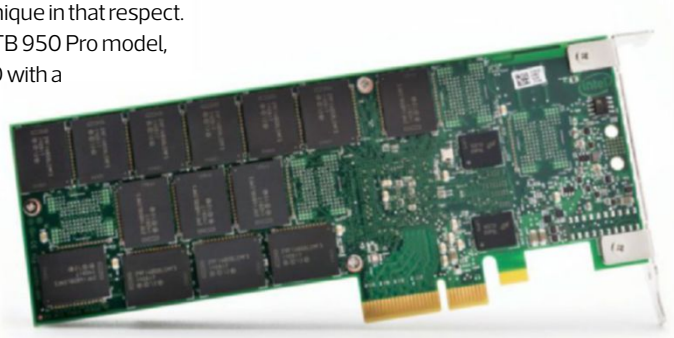
The 1.2TB SSD 750 also carries a price tag that's well over double that of any other PCI-E SSD, and three times the cost of the 512GB 950 Pro. Notably, though, there aren't many PCI-E drives that offer capacities above 512GB, so this SSD is unique in that respect.

In the absence of a 1TB 950 Pro model, if you want a PCI-E SSD with a large capacity, you'll need to dig deep into your pocket.

In terms of the hardware itself, the 20nm 2-bit MLC NAND is branded by Intel, coming in the form of 18 NAND packages. These packages pair up with the 18-channel, four-lane Intel CH29AE41AB0 PCI-E controller, which has been carried over in part from Intel's P3700 datacentre drive. The large metal casing is really a large heatsink covering the controller and some of the NAND flash, with the remaining chips placed on the underside of the card.

The 750 Series claims the top spot in many of our tests, beating even the Samsung 950 Pro. Of particular note is Iometer, where the 750 Series delivers results that blow away any other SSD on the market, with 262,787 IOPS. Compare that result to the 139,096 figure of the 950 Pro, which is already much higher than the other SSDs on test. The SATA drives languish around the 40,000 mark, so this is an amazing result.

Sequential read and write speeds are impressive too, although the 950 Pro generally has an advantage in these tests, with a notable exception being write speeds, where the Intel drive has the advantage. In the PCMark traces and BootRacer tests, however, the advantages of the 750 Series are less clear. It was the slowest drive on test for a cold boot, and plays second fiddle to the 950 Pro in every trace. In short, this drive's massive capacity, incredible IOPS and high pricing mean it's really engineered for specific power-user workloads, rather than general desktop use.



Conclusion

There's a lot to like about the 750 Series. It's the only PCI-E 3 drive that comes in capacities over 1TB, and it goes like the clappers in sequential read and write tests, with very impressive IOPS results. It's also the most expensive drive on test, though, and most consumer desktop users are unlikely to see any benefits from it, particularly when you consider the comparatively slow boot time.

If you're a serious power user, then the Intel 750 is a very fast, high-capacity drive, but for everyone else, the Samsung 950 Pro offers better value for money and, with an M.2 version, is also a more practical upgrade for anyone with an X99 or Z170 motherboard.

VERDICT

An extremely fast and high-capacity drive that's great for power users, but it has slow boot times and, for general use, the Samsung 950 Pro offers much better value.

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
48/50	8/20	26/30	82%

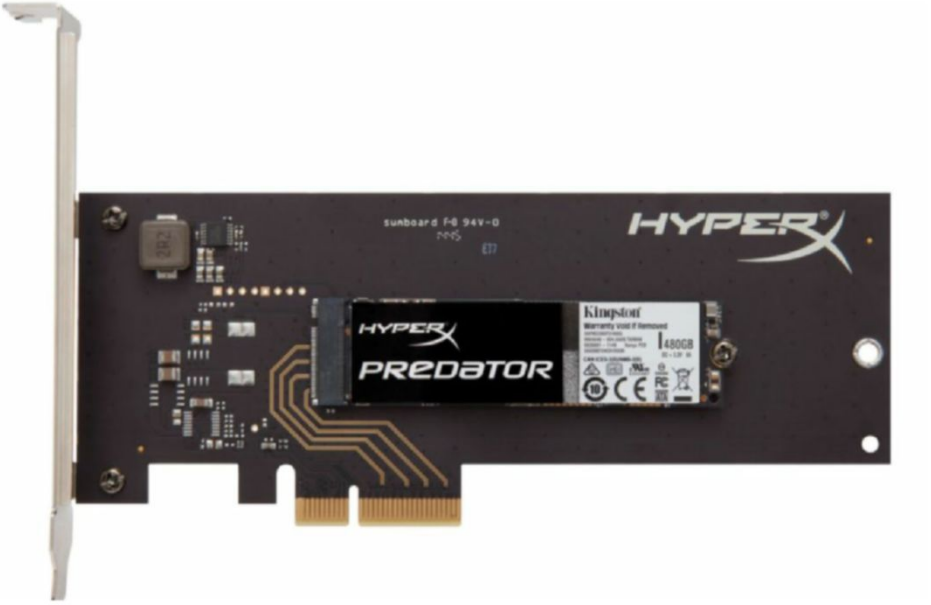
Kingston HyperX Predator

Kingston HyperX Predator M.2 240GB / £158 inc VAT (£200 inc VAT with add-in card)

SUPPLIER www.ebuyer.com

Kingston HyperX Predator 480GB add-in card / £340 inc VAT

SUPPLIER www.ebuyer.com



Until the launch of the Samsung 950 Pro, Kingston's HyperX Predator M.2 was the fastest consumer-focused PCI-E M.2 SSD you could buy, excluding OEM models or add-in cards. With four PCE-E 2 lanes, it doesn't offer the headroom you get with newer PCI-E 3 devices, though, so it's going to be significantly slower than Samsung's 950 Pro on Intel's X99 and Z170 chipsets.

On the plus side, the Kingston HyperX Predator's performance is clearly quicker than SATA M.2 SSDs. However, the significant speed boost offered by Samsung's 950 makes the HyperX Predator look overpriced and slightly outdated.

While the Predator M.2 uses the PCI-E bus, it uses the AHCI protocol rather than NVMe. While this choice will affect performance, it does mean the drive can be used for booting from a wider range of motherboards. It can be purchased with a half-height, half-length add-in card adaptor for use in a standard PCI-E slot too, so you can use it with practically any motherboard. The drive can also be removed from this slot and inserted directly into an M.2 slot on your motherboard, if you prefer.

The HyperX Predator uses a Marvell 88SS9293 controller, coupled with Toshiba A19nm 2-bit MLC NAND flash. The only two capacities available are 240GB and 480GB, which shrink down to 224GB and 447GB when formatted.

Despite its reliance on the last generation's top-end technology, the Predator achieves some good results. Sequential reads break the 1,400MB/sec barrier, and the 480GB model manages 1,000MB/sec writes.

However, the 240GB model sees a severe drop in write performance to just 673MB/sec, which isn't much faster than a SATA drive.

Both drives perform fairly well in other tests though. Average IOPS measured in Iometer show a gain over the SATA-based M.2 SSDs on test, although the performance boost is only around 25 per cent, and you get much better IOPS results from Samsung and Intel's new PCI-E drives. Move up to the Samsung 950 Pro, and the results are more than double those of the Predator M.2.

In the PCMark trace tests, the Predator M.2 sits close to the top, but it's again beaten by the 950 Pro. In these real-world tests, though, the difference between the drives is one or two seconds– the same gap we see from moving from SATA-based SSDs to PCI-E drives in general.

While the Kingston HyperX Predator M.2 offers reasonable performance results, they can't match Samsung's 950 Pro, which is to be expected when the latter uses PCI-E 3 and NVMe. Unfortunately, though, the Hyper X Predator M.2 is more expensive than the latter. Although the 240GB Predator M.2 is only slightly more expensive than the 256GB 950 Pro, there's a price difference of £100 between the 480GB Predator M.2 and the 512GB 950 Pro, while the 950 Pro carries a five-year warranty, compared with only three years for the Predator M.2. It's another part of the package that doesn't quite measure up when you consider the price.

Conclusion

The Kingston HyperX Predator loses out due to its reliance on the older PCI-E 2 standard. It's still a fast SSD, and capable of impressive performance compared with traditional SATA-based drives, but the PCI-E 3-based 950 Pro beats it soundly in terms of both performance and value for money. It's worth considering a HyperX Predator if you have an older motherboard and want to boot from a PCI-E SSD, but for those with an X99 or Z170 board, the Samsung 950 Pro is the clear choice.

VERDICT

A decent speed boost over SATA drives, but it's far too pricey compared with the PCI-E 3 competition.

KINGSTON HYPERX PREDATOR M.2 240GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
35/50	8/20	19/30	62%

KINGSTON HYPERX PREDATOR AIC 480GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
37/50	7/20	19/30	63%

Decoding M.2 and NVMe

PCI-E storage smashes the current SATA bottleneck, but there's a confusing mess of standards and terms, which we explain here

When SATA ports first appeared on motherboards over a decade ago, it was a welcome solution to a long-standing storage nightmare with PCs. The long 40-pin IDE connector occupied a lot of space on motherboards, limited the number of storage devices to four, and relied on a master/slave configuration, with a jumper that had to be set correctly for a device to be recognised. The pins bent all too easily and were a constant cause of headaches for PC builders.

Younger readers might be grateful to have never experienced these problems, but computers and storage technology have once again moved on since the introduction of SATA. The SATA standard has gone through three revisions, each raising the performance headroom it provides, with modern SATA III devices offering 6Gb/sec of bandwidth.

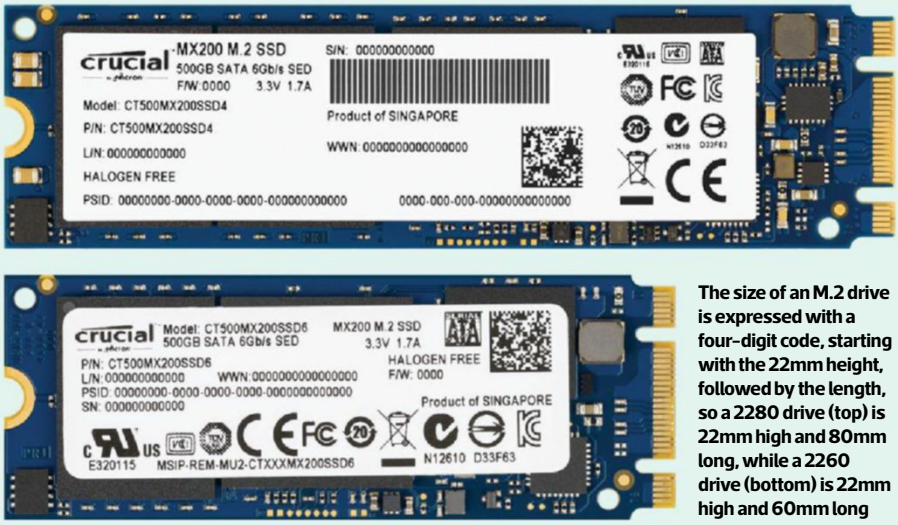
This bandwidth is easily sufficient for hard disks, where even the best sequential transfer speeds of around 200MB/sec are well within the limit, but today's hot storage technology is no longer based on mechanical disk platters, but NAND flash memory that's capable of much faster performance.

Due to the limitation of the SATA bus, most 2.5in SATA SSDs have now hit a performance ceiling, with sequential transfer speeds stuck at around 550MB/sec, and they can't go any faster with the current SATA standard.

Raising this ceiling with a new, faster SATA revision would have solved this issue temporarily, only for it to return again once that extra bandwidth was used up.

All this time, SATA has coexisted with the much faster PCI-E bus, which provides more bandwidth over a number of lanes, via a more direct interface with the CPU subsystem.

Moving storage from SATA to PCI-E means better performance, but it also creates a problem. Traditional PCI-E expansion cards can be used for storage, but only in desktop computers. A new connector was needed, with dimensions small enough for storage devices to fit into mobile computers as well as desktop PCs. That connector is called M.2. It can access both the PCI-E and SATA buses and carries both power and data. It requires no cabling, since devices plug directly into the slot.



The size of an M.2 drive is expressed with a four-digit code, starting with the 22mm height, followed by the length, so a 2280 drive (top) is 22mm high and 80mm long, while a 2260 drive (bottom) is 22mm high and 60mm long

It first appeared on PC motherboards with the Z97 chipset in 2014, but it's also present on X99 boards and the new Z170 boards that launched with Intel's Skylake processors.

M.2, developed mainly for mobile applications as an upgrade to mSATA, was initially called 'next-generation form factor' and its scope is intended to be wider than just storage. Wireless adaptors, mobile data and Bluetooth adaptors are all supported, with each class of M.2 device denoted by the position of the notch along its pins. SSDs universally adopt the 'M' and 'B' key notch position.

> NVMe has been specifically optimised for SSDs to exploit their inherent parallelism

M.2 SSDs come in a small stick format and, so far, no device has had any casing covering the NAND chips. They can be either single or double-sided, and not all M.2 devices are the same length. Their size is described by listing the width (usually 22) and length in millimetres; a 2280 device is 80mm long, while a 22110 device is 110mm long. The norm for SSDs is 2280 (with some available in both 2280 and 2260 formats), but not all motherboards will accommodate a 2280 SSD, so your first job is to check what size of device your board can support.

New protocols

At the same time, the low-level AHCI bus protocol, which governs how a storage device communicates with the CPU, was designed at a time when flash memory couldn't offer the performance, reliability, affordability or capacity needed for a computer's operating system installation. Its specification was based on the limitations of hard disks, which can only ever read one piece of data at a time, after a head has moved into position over the disk. There would be no need for a queue of more than 32 commands, and with single-core processors, no need for multiple queues, as only one thread could perform I/O operations at any time.

On some PCI-E SSDs, though, AHCI has also been replaced with a new bus protocol called NVMe. NVMe has been specifically optimised for SSDs to exploit the parallelism inherent in their design. Queues are now extended to 65,536 commands, and the protocol supports 65,536 queues, which works out to be far more I/O commands than

AHCI can handle. There are fewer register accesses per command, leading to lower latency, and there's no thread locking, which leads to greater parallelism and improved use of today's multi-core CPUs.

Booting from an NVMe SSD, however, requires motherboard support, which is usually only present in boards based on the Z97 chipset or later, although some manufacturers may release BIOS updates enabling support on older boards. You should still be able to use an NVMe drive on an older board, but you won't be able to boot from it. For Windows to recognise the drive, it also needs an NVMe driver, which Microsoft provides with Windows 7 via an update or natively in Windows 8.1 and 10. Note that some manufacturers (such as Samsung) also provide their own NVMe drivers to boost speed and enable advanced features, such as firmware upgrades and secure erase.

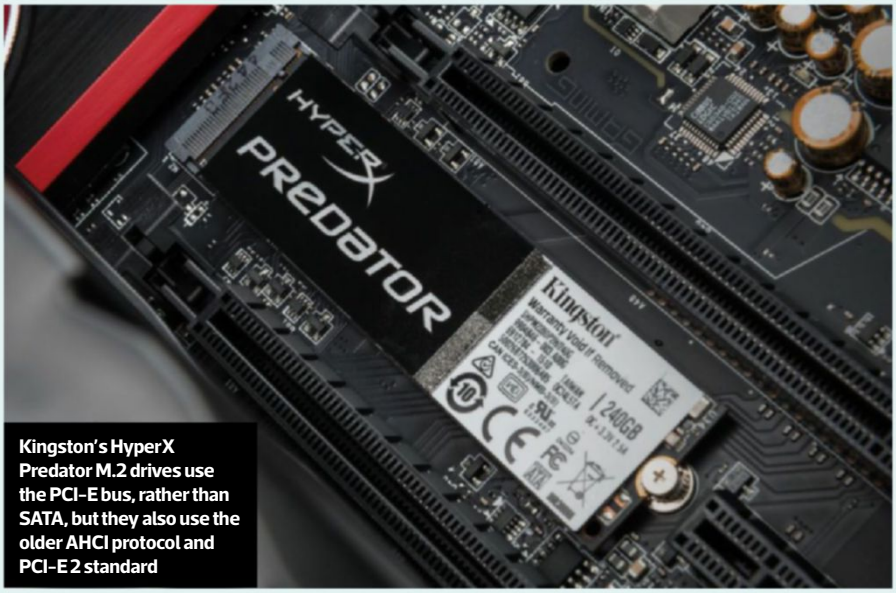
To make matters even more complicated, there's also the U.2 standard, which hooks up to Intel's latest 2.5in SSDs

Confusing times

By introducing a number of separate standards at the same time, the industry has created a confusing situation. There are now M.2 SSDs that use the PCI-E bus, which gives them additional headroom for faster transfer rates. But there are also M.2 SSDs that use the SATA 6Gbps bus, with the same performance limitations as a traditional 2.5in SATA device.

Unfortunately, the situation gets even more complicated. Older PCI-E SSDs use two PCI-E 2 lanes, which run at 4Gb/sec each for a total of 8Gb/sec of bandwidth, while newer SSDs use up to four PCI-E 3 lanes, which run at 7.87Gb/sec for a total potential bandwidth of 31.5Gb/sec – a massive increase over SATA 6Gbps. So before purchasing, make sure your M.2 slot supports the same PCI-E standards as your SSD to ensure compatibility and full speed.

Meanwhile, PCI-E SSD cards that slot into a standard PCI-E slot have been around for a few years now, usually in the form of a half-height, half-length (HHHL) card. For now, this form factor coexists with M.2 devices. You can also buy M.2 add-in card adaptors, which can be useful if you have an older motherboard that doesn't have an M.2 slot, and with some motherboards, you can create a RAID array with M.2 devices using an adaptor and the on-board slot. Again, though, bear in mind that older motherboards may not be able to boot from a PCI-E NVMe add-in card.

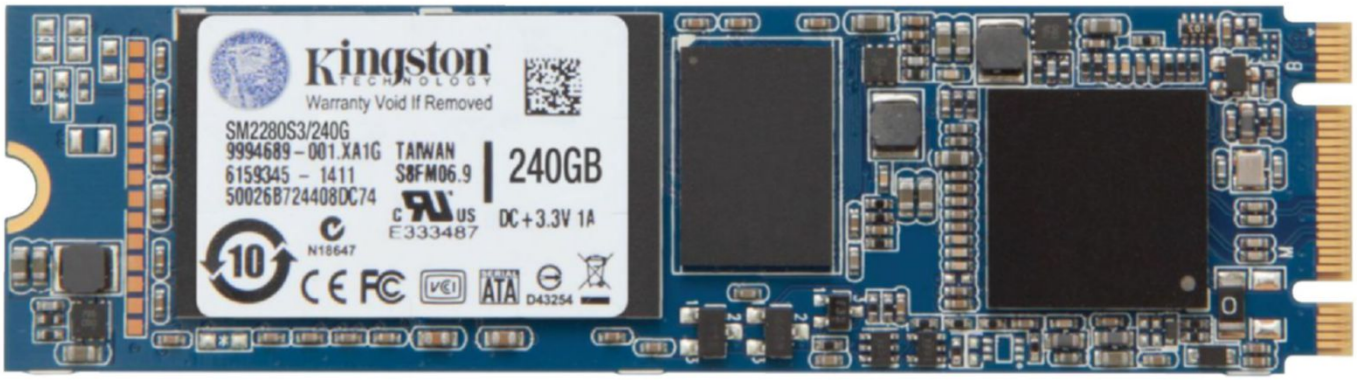


Kingston's HyperX Predator M.2 drives use the PCI-E bus, rather than SATA, but they also use the older AHCI protocol and PCI-E 2 standard

The result of all the above is a very confusing collection of standards supported in two form factors. All the M.2 SATA drives we've seen use the AHCI protocol, but we've seen PCI-E SSDs that use AHCI too, rather than NVMe, which can also impact performance. You need to look closely at the standards supported by both your drive and your motherboard to make sure you'll get the most out of them.

To make matters even more complicated, here's one more standard to mention too, called U.2 (formerly SFF-8369), which is a new connector used on 2.5in devices. It has the same number of pins as a SATA Express connector, which it's designed to supersede.

It offers backwards compatibility with SATA SSDs and exposes four PCI-E 3 lanes for up to 31.5Gb/sec of bandwidth. So far, however, only Intel's SSD 750 can be purchased in this form factor and there are currently few motherboards that support the standard.



Kingston SSDNow M.2 240GB / £85 inc VAT

SUPPLIER www.cclonline.com

The 2.5in versions of Kingston's SSDNow drives have been around for quite some time, aimed squarely at the entry-level end of the market. The drives originally launched back in 2009, when the SSD market was in a nascent stage and the majority of people's computers still relied on a mechanical hard disk for their operating system files, and an SSD was an expensive extravagance. It comes as no surprise, then, that the SSDNow M.2 bears little similarity to the older 2.5in drives, aside from its branding and the continued focus on the entry-level end of the market.

Also known as the SM2280S3, the Kingston SSDNow M.2 240GB is a double-sided 2280 M.2 SATA drive, and it uses the AHCI bus protocol rather than NVMe. Being a SATA drive, it's aimed at the opposite end of the market from the high-end Predator M.2 SSD, which has a PCI-E interface for faster speeds, but also a much higher price.

The SSDNow's 8-channel controller is called the PS3108-S8, and it comes from Taiwanese firm Phison. We've tested the 240GB flavour of the drive, but there are also 120GB and 480GB versions available. In the case of the 240GB drive, four rebranded 64GB Toshiba A19nm chips make up the storage, which totals 224GB after formatting.

Like all SSD manufacturers, Kingston also offers its own Toolbox SSD maintenance software for download on its website. It's fairly rudimentary, but it covers all the essentials. Firmware updates, SMART monitoring and diagnostic scans are part of the show, with a secure erase function added as well.

As an entry-level SATA drive, the SSDNow M.2 goes up against the Crucial MX200, Transcend MTS800 M.2 and Samsung 850 Evo M.2, but it's outperformed by all these drives in most of our performance tests.

> Sequential read speed is a relatively strong point, with a solid result of 531MB/sec

While the sequential read speed is a relatively strong point, with the SSDNow M.2 achieving a solid result of 531MB/sec, it drops down fast in sequential write tests to just 355MB/sec, while other SATA M.2 devices can meet 500MB/sec. There are plenty of 2.5in SATA drives that offer faster write speeds.

Meanwhile, its result in Iometer came to just 23,512 IOPS, which is less than half the speed of even the slowest PCI-E M.2 drives on test, and slower than any of the other SATA drives too, with a gap of at least 10,000 although, to be fair, the SSDNow clearly isn't designed for high IOPS performance.

The SSDNow M.2 also found its place in the middle of the pack in some of our PCMark real-world tests.

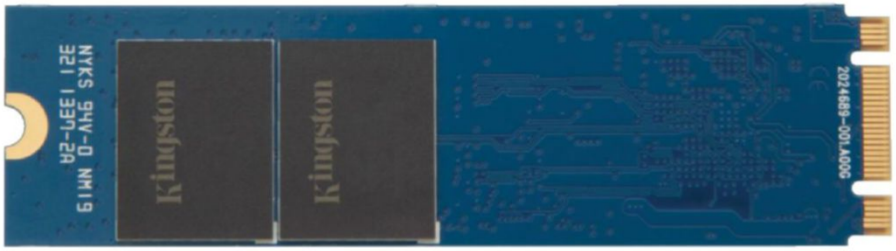
Even here, though, it was generally the same story as with the synthetic tests, with the SSDNow M.2 failing to deliver a single result that could be considered impressive.

The SSDNow M.2 even came in last place in the BootRacer fast boot test, with a time of 14.8 seconds, 1.5 seconds slower than Kingston's other drive on test, the Hyper X Predator AIC 480GB. In short, you can get superior performance and better value for money elsewhere.

Conclusion

Although the SSDNow M.2 has a deceptively low price per gigabyte, it's matched or beaten by cheaper alternatives that perform far better. The Crucial MX200 250GB is £10 cheaper, but outperforms the SSDNow M.2 in every test, as does Samsung's SSD 850 Evo, for the same money.

The good value in terms of capacity is basically offset by a relatively uncompetitive bang per buck. If you're looking for a cheap M.2 drive, the cheaper and faster Crucial MX200 250GB is a better buy.



VERDICT

Good value in terms of capacity, but not a great performer. Crucial's MX200 M.2 is both cheaper and faster.

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
29/50	17/20	23/30	69%

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Plextor M6e Black Edition 256GB / £220 inc VAT

SUPPLIER www.amazon.co.uk

Whenever a new disruptive product is launched that seriously outclasses its competition, it instantly alters the landscape of that market. It doesn't mean alternative products cease to become a worthwhile purchase, but it often forces them to compete in terms of pricing and value for money rather than performance. Anything that costs more money than the new killer product, or even costs the same amount, without any inherent advantage, instantly becomes uncompetitive. With SSDs, that new product is Samsung's 950 Pro, so Plextor's M6e Black Edition, with its price of £220 inc VAT, is now up against some serious competition.

The 950 Pro has set a standard against which all other drives will undoubtedly be compared, thanks to the raw performance it offers, courtesy of four PCI-E 3 lanes. If Plextor had significantly dropped the price of the M6e Black Edition, it would be in with a chance, but it has its work cut out with its price of £220 inc VAT for a 256GB drive, giving it the highest cost per gigabyte on test.

The M6e ships as a PCI-E add-in card, sporting a very attractive design, with a bright red heavy-duty heatsink on top of a black metal casing over the PCB. Remove this casing and you'll see the M6e sitting underneath it as a standard M.2 device; if you wish, this can be removed and placed into a motherboard's M.2 slot.

It comes in three capacities from 128GB to 512GB, and uses four 500MB/sec PCI-E 2 lanes. It also has the same Marvell 88SS9183 controller used in a multitude of other SSDs, including the Crucial MX200 M.2, and Toshiba 19nm Toggle NAND flash memory, which isn't quite as up to date as the advanced A19nm NAND flash used in many other drives.

With only half the available bandwidth of a PCI-E 3 device, the M6e Black Edition sits in the same boat as Kingston's HyperX Predator, and simply can't match the performance of Intel's 750 Series or Samsung's 950 Pro, which use four PCI-E 3 lanes and the NVMe protocol.

The Plextor at least offers some reasonable 32-queue-depth read and write performance, with results that sit comfortably beyond what you can achieve from a SATA SSD. However, its write speeds aren't as impressive, only overtaking Samsung's SATA-based 850 Evo by a small margin.

Notably, the 950 Pro achieves read results that are three times those of the M6e and write results that are twice as high. It's the same story in the PCMark traces, where the M6e edges slightly ahead of the SATA drives, but only barely, while the latest PCI-E 3 drives beat it soundly.

Unfortunately, the M6e Black Edition's pricing is still stuck in an era when companies could charge a significant premium for PCI-E-level performance, which made sense when it was up against SATA drives, but is impossible to justify next to the Samsung 950 Pro. The 256GB M6e model on test costs only £38 less than Samsung's 512GB 950 Pro, and it's also the only 256GB drive priced over £200. Couple this high cost per gigabyte with middling performance, and it's clear you can get a better deal elsewhere.

Conclusion

The M6e would have looked impressive a year ago, when there was less PCI-E competition and SATA drives were commonplace, but you can now buy cheaper drives that offer significantly faster performance.

With the highest cost per gigabyte on test and middling performance, the M6e Black Edition is in desperate need of a price cut if it's going to compete with Samsung's latest and greatest.

VERDICT

An improvement on SATA drives, but the extremely high cost per gigabyte and middling performance make the M6e very uncompetitive in the wake of PCI-E 3 drives.

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
33/50	3/20	15/30	51%

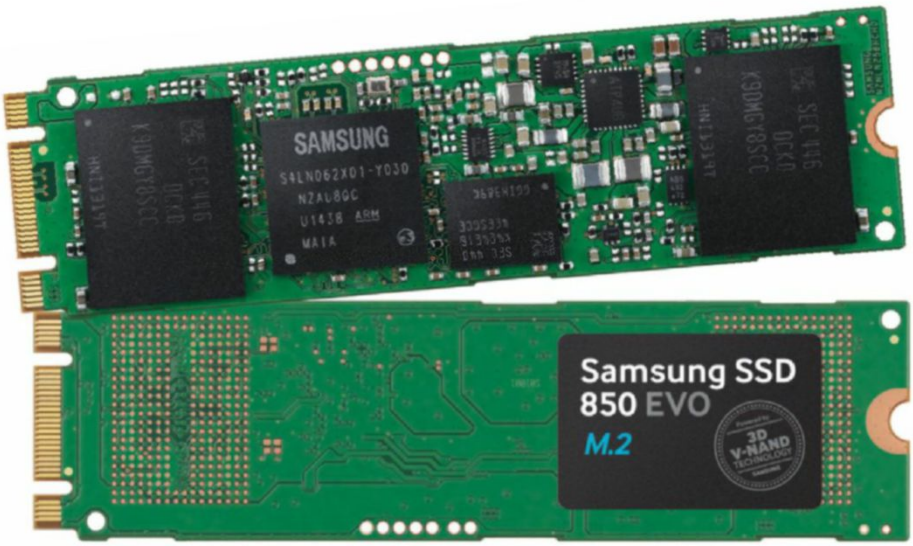
Samsung SSD 850 Evo

Samsung SSD 850 Evo 250GB / £80 inc VAT

SUPPLIER www.box.com

Samsung SSD 850 Evo 500GB / £139 inc VAT

SUPPLIER www.amazon.co.uk



The M.2 versions of Samsung's SSD 850 Evo drives lift most of the technology and features from the 2.5in 850 Evo drives and place them into a much smaller, 2280-format M.2 cards. However, these M.2 drives use the SATA bus rather than PCI-E, and use the AHCI bus protocol rather than NVMe. It's the same approach used by a few manufacturers, notably Crucial with the M.2 version of the MX200.

The M.2 850 Evo drives also share the interesting NAND flash configuration of their 2.5in counterparts. They use the same second-generation Samsung 32-layer V-NAND as the company's 850 Pro and 950 Pro drives, with all the advantages of improved longevity and performance. However, in the 850 Evo drives, the NAND is configured as TLC, or 3-bit MLC, with an SLC cache called TurboWrite.

The performance and longevity of NAND flash memory is very much affected by the number of bits each cell holds, since the more bits per cell, the more writes the cell will have to endure.

That's why the efficient SLC (1-bit per cell) cache is needed. All incoming writes go to this cache first before being flushed to the TLC portion. For most small writes, only the high-performance SLC cache will be used, and the Samsung 850 Evo will be as fast as any other drive.

The different 850 Evo M.2 capacities have varying quantities of NAND reserved as SLC cache: the 120GB and 250GB 850 Evo M.2 models have 3GB, while the 500GB model has 6GB. Likewise, the dual-core Samsung MGX controller has carried over from the 2.5in drives, along with 512MB of LPDDR3 as memory cache.

In terms of price, the 850 Evo M.2 is only slightly more expensive than the Crucial MX200, and is the second cheapest M.2 drive on test. In terms of cost per gigabyte, it scores well, with the 500GB variant offering better value than the 250GB drive, a trend we've seen with other SSD families too.

In our benchmarks, the M.2 version of the 850 Evo delivers in both synthetic tests and the PCMark traces, with the best overall results of all the SATA-based M.2 drives. It comes out slightly ahead of Crucial's MX200 M.2, and performs significantly better than the Transcend MTS800 M.2 and Kingston SSDNow M.2 in most of the 32-queue-depth and random tests.

> The NAND is configured as TLC, or 3-bit MLC, with an SLC cache called TurboWrite

There are a few exceptions, though. It isn't the fastest SATA drive when it comes to sequential reads, falling behind Transcend's MTS800, and its average IOPS recorded in Iometer is lower than the result from Crucial's MX200.

Overall, however, it's a very strong showing for a SATA drive at this price. Plus, like the 950 Pro, the 850 Evo is supported by Samsung's excellent companion toolbox software called Magician. It has a five-year warranty too.

Conclusion

Choosing between Crucial's MX200 or Samsung's 850 Evo is a tough decision, since both drives are similarly priced, and most of the performance results are close enough to be called a photo finish. Both drives offer excellent SATA M.2 performance at a very reasonable price.

The lower cost of the Crucial MX200 just gives it the edge in this particular league, but the Samsung Evo 850's excellent Magician software also makes it well worth considering, depending on your priorities. As with the Crucial MX200, the 500GB version of the Samsung 850 Evo also offers better value than the 250GB variant.

VERDICT

A great-value SATA M.2 drive with solid performance and great software.

SAMSUNG SSD 850 EVO 250GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
31/50	18/20	27/30	76%

SAMSUNG SSD 850 EVO 500GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
32/50	19/20	29/30	80%

Samsung SSD 950 Pro

Samsung SSD 950 Pro 256GB / £147 inc VAT

SUPPLIER www.ebuyer.com

Samsung SSD 950 Pro 512GB / £261 inc VAT

SUPPLIER www.dabs.com

Samsung's SSD 950 Pro breaks new ground in a few areas, being the company's first consumer M.2 drive to use four PCI-E 3 lanes for the fastest possible performance. It joins the Intel SSD 750 in being one of only two drives on test to take advantage of the 1GB/sec per channel offered by PCI-E 3 lanes. It also uses the NVMe protocol, a first for Samsung in the consumer M.2 arena, although an updated version of the enterprise-grade SM951 also supports NVMe.

The 950 Pro sports a triple-core MBX controller running at 500 MHz, with 512MB of LPDDR3 cache memory across both of the capacities on offer – 256GB and 512GB. Meanwhile, the 2-bit MLC V-NAND is the second-generation 32-layer variant, similar to the flash memory used in the 850 Pro and other Samsung drives.

Like many other M.2 drives, it comes in a 2280 single-sided format, with no room for additional die packages to increase capacity beyond 512GB, and therefore a 1TB version isn't planned until Samsung ramps up production of its higher-density, 48-layer V-NAND chips next year.

Then there's Samsung's Magician software, which offers the usual firmware updates and quick access to SMART data, but there's also a built-in benchmarking tool, secure erase and memory caching for a further performance boost, called Rapid mode. It's tied into a very polished interface, and stands out as a strong offering among competing SSD toolbox software.

The 950 Pro dominates in six of our performance tests, with the 512GB model coming out in front of the 256GB drive every time. Interestingly, there's a far bigger difference between the performance of the 256GB and 512GB capacities of 950 Pro than any other SSD family on test. In sequential 32-queue-depth writes, the difference is a significant 500MB/sec, with the 256GB capacity offering 981MB/sec, and the 512GB drive managing 1,529 MB/sec. The gap narrows a little with sequential reads, but in the Iometer tests, this same difference can be seen again, with the 512GB model's IOPS result being around a third quicker.

> Sequential read and write speeds are off the scale compared the other PCI-E drives

Although Intel's SSD 750 Series claims the top spot in many of the tests, both the 256GB and 512GB 950 Pro dominate any other drive of the same capacity in the majority of the remaining tests, and usually by a wide margin. The notable exceptions are BootRacer and 32-queue-depth random writes, where the 950 Pro doesn't look quite as impressive, although these results are still very good.

Its sequential read and write speeds are off the scale compared with even the other PCI-E drives. Kingston's HyperX Predator 480GB, for example, manages a still impressive 1,453MB/sec sequential read, but the result for the 950 Pro 512GB is 50 per cent higher, with 2,331MB/sec. In every PCMark trace, both 950 Pro drives also take the top two spots, in some cases shaving a few seconds off the result of the next fastest drive.

Perhaps most importantly, though, the speeds offered by the 950 Pro are a true showcase of what can be achieved from M.2 PCI-E SSDs, when for years we've been limited by the comparatively restricted speed of the SATA bus.

Conclusion

The Samsung 950 Pro is unquestionably the pinnacle of M.2 PCI-E solid state storage, offering amazing performance for a very reasonable price. That said, the 512GB variant offers a significantly better deal than the 256GB drive, in terms of both speed and bang per buck. If you have an X99 or Z170 motherboard with a 2280M.2 slot, the Samsung SSD 950 Pro 512GB is the SSD to buy for it.

VERDICT

The best M.2 drive on test, but the 512GB version offers superior performance and value compared with the 256GB drive.

SAMSUNG SSD 950 PRO 256GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
42/50	11/20	25/30	78%

SAMSUNG SSD 950 PRO 512GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
44/50	12/20	29/30	85%

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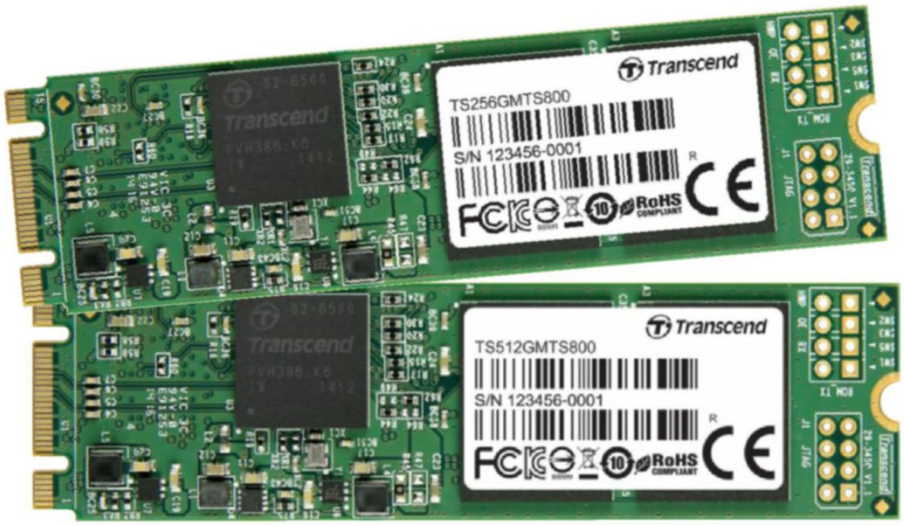
Transcend MTS800 M.2

Transcend MTS800 M.2 512GB / £187 inc VAT

SUPPLIER www.amazon.co.uk

Transcend MTS800 M.2 256GB / £90 inc VAT

SUPPLIER www.lambda-tek.com



Although most storage firms are moving towards higher SSD capacities, chopping even 128GB flavours from their line-ups, Transcend is clearly still keen to cater for those users who absolutely don't care about huge amounts of flash memory storage. Accordingly, the SATA-based MTS800 M.2 series is available in five capacities, including just 32GB, a capacity that could only be useful in extremely cheap laptops.

It's the 256GB and 512GB models that most interest us, though, as you then have enough room to install Windows, plenty of software and some games, with the latter occupying increasingly large capacities as games become ever more complex.

Transcends MTS800 drives use a Silicon Motion SM2246EN SATA controller branded as a Transcend TS6500, as used in the firm's 2.5in drives. Likewise, Transcend also uses third-party flash memory – in this case, 20nm Micron 2-bit MLC. The chips are placed on both sides of the 2280 M.2 card, a break from what seems to be the norm for M.2 SSDs, with most manufacturers instead opting for single-sided placement. After overprovisioning, you're left with 238GB of formatted space with the 256GB model, and 477GB with the 512GB model.

There are a few other features worth mentioning. There's full-drive encryption and an additional circuit for data protection in the event of power loss, but the SSD Scope software has one feature sorely missing from the efforts of other manufacturers – system cloning, so you can back up your operating system from an existing hard disk onto the MTS800. If other manufacturers offer this feature, they usually do so by bundling third-party software in the box, usually from Acronis.

As an entry-level SATA M.2 drive, the MTS800 is competing on price with the likes of the Samsung 850 Evo M.2 and Crucial MX200 M.2, but these drives are both notably cheaper than the equivalent MTS800 models.

Unfortunately, this extra premium doesn't translate into better performance, though,

There's full-drive encryption and an additional circuit for data protection

and in some cases, the very opposite. In a few of the synthetic tests, the MTS800 is at the bottom of the pile, or near to it, with only Kingston's SSDNow M.2 achieving consistently lower results.

Although the sequential read speeds look okay at first glance, the MTS800 drives' 32-queue-depth write speed languishes behind other drives.

Meanwhile, the mixed workloads Iometer test yielded an IOPS result of just 40,000 for both capacities on test – one of the lowest results we recorded this month. The 256GB model also comes bottom in some tests, including the Microsoft Word and Photoshop Heavy sections of PCMark 8.

There's no reason a SATA-based SSD that uses the M.2 form factor will perform any better than a 2.5in SATA drive, of course, but you'd at least expect it to outperform decent 2.5in drives. Sadly, though, some of the MTS800 results sit well below what we'd expect from decent 2.5in drives.

The 32-queue-depth sequential write result of 318MB/sec, for example, is well behind the competition.

Conclusion

While it's far from a terrible drive, the Transcend MTS800 is eclipsed by competing M.2 SSDs, whether SATA-based or PCI-E, particularly Samsung's 850 Evo or Crucial's MX200. If you want to avoid the significant premium for increased PCI-E performance by opting for a SATA drive, or if you want the wide compatibility of a SATA drive, both the aforementioned Crucial and Samsung drives offer faster speeds than the Transcend MTS800, and for less money too.

VERDICT

Tempting prices for the capacities on offer, but the competition from Samsung and Crucial eclipses the MTS800 in terms of both performance and value for money.

TRANSCEND MTS800 M.2 256GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
30/50	17/20	24/30	71%

TRANSCEND MTS800 M.2 512GB

SPEED	£/GB	BANG/BUCK	OVERALL SCORE
31/50	16/20	24/30	71%

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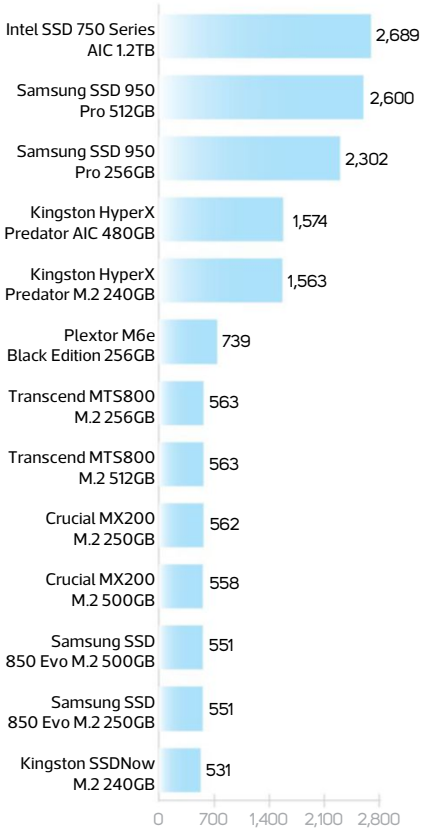
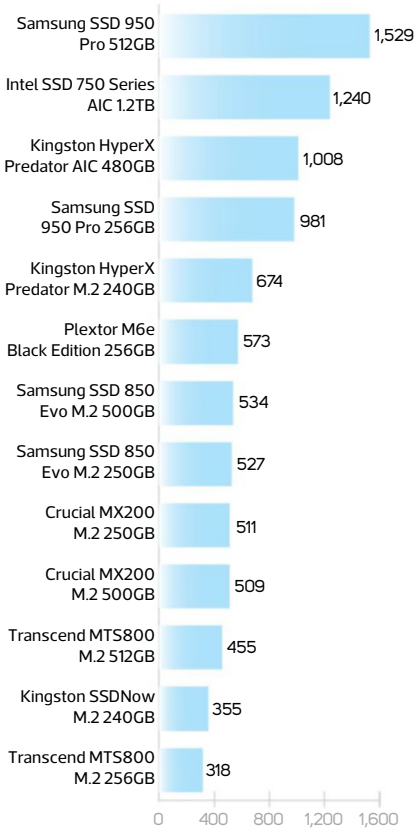
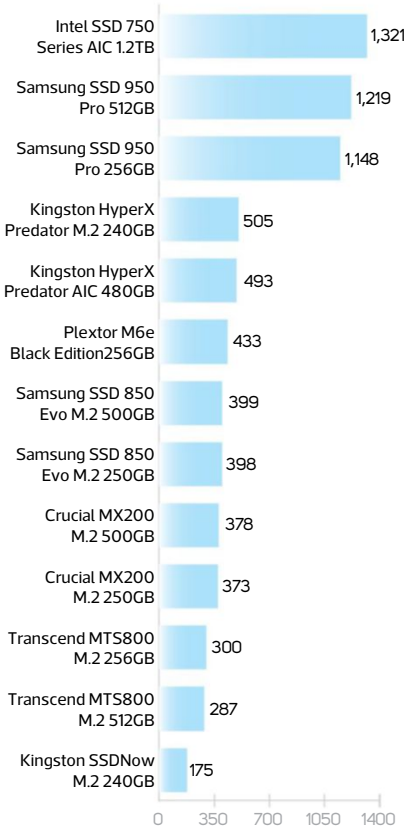
Sequential read QD32 (MB/sec)



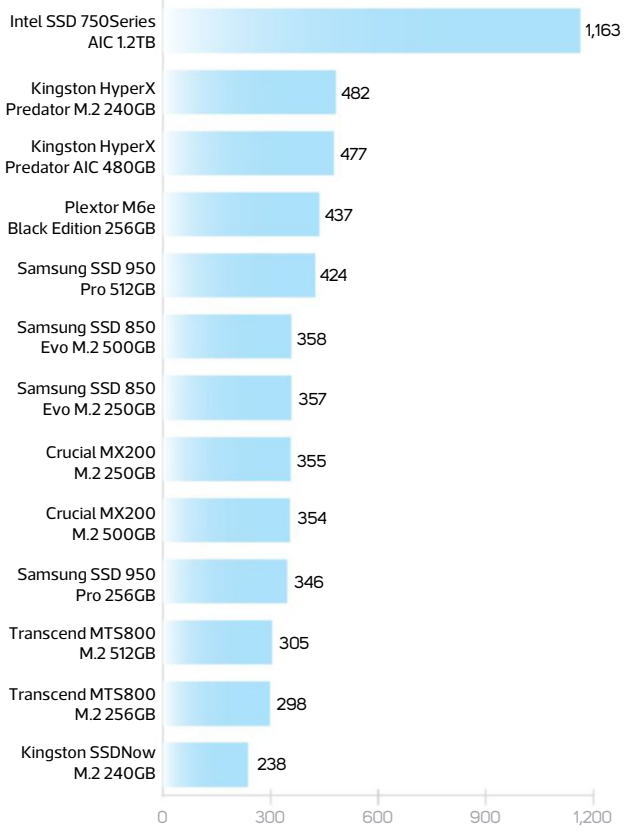
CRYSTALDISKMARK 5.0.2
Sequential write QD32 (MB/sec)



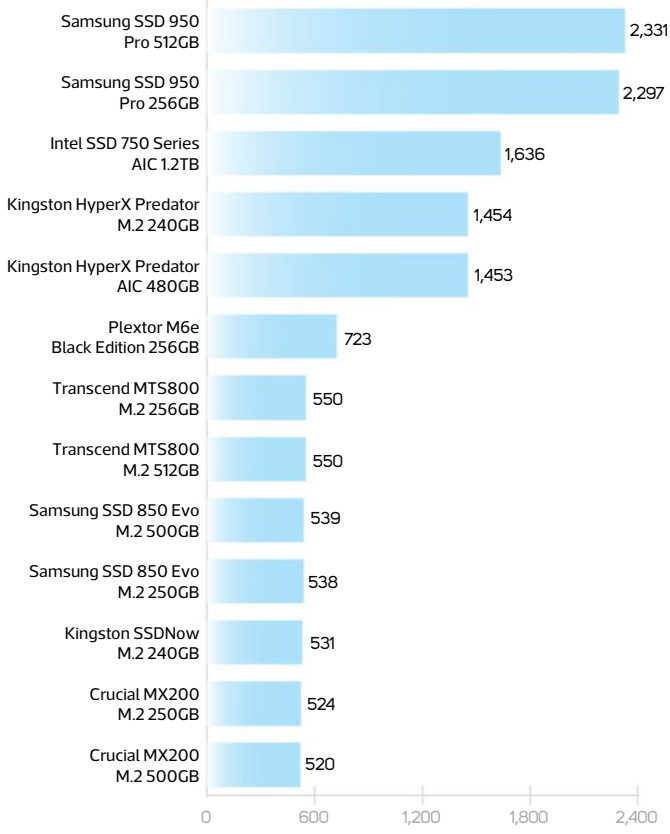
CRYSTALDISKMARK 5.0.2
Random read QD32, 4 threads (MB/sec)



CRYSTALDISKMARK 5.0.2
Random write QD32, 4 threads (MB/sec)



CRYSTALDISKMARK 5.0.2
Sequential read (MB/sec)



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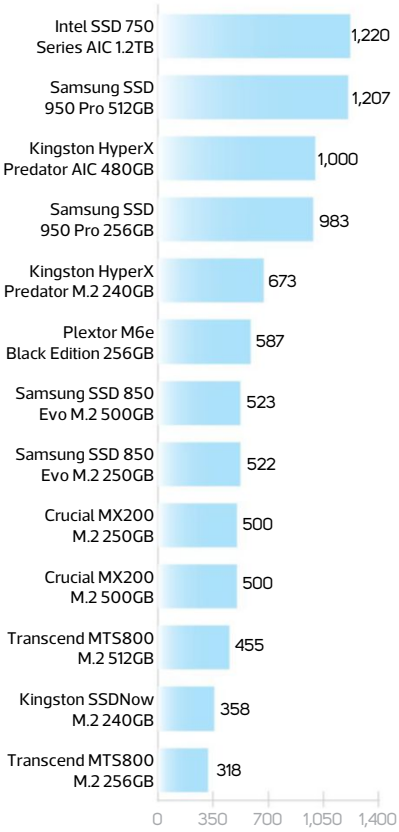
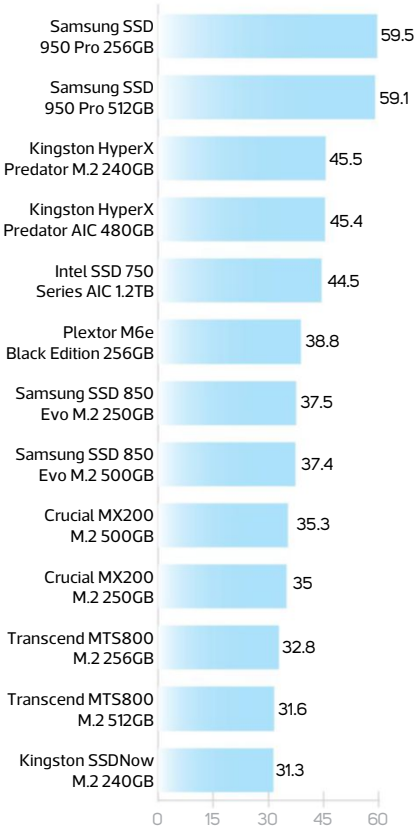
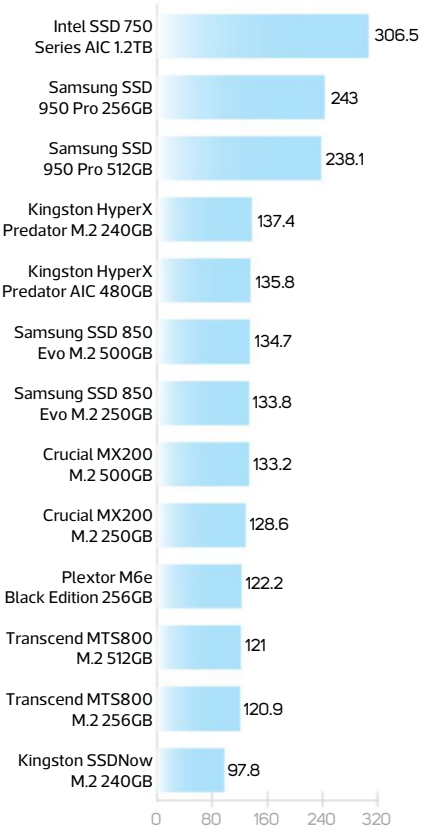


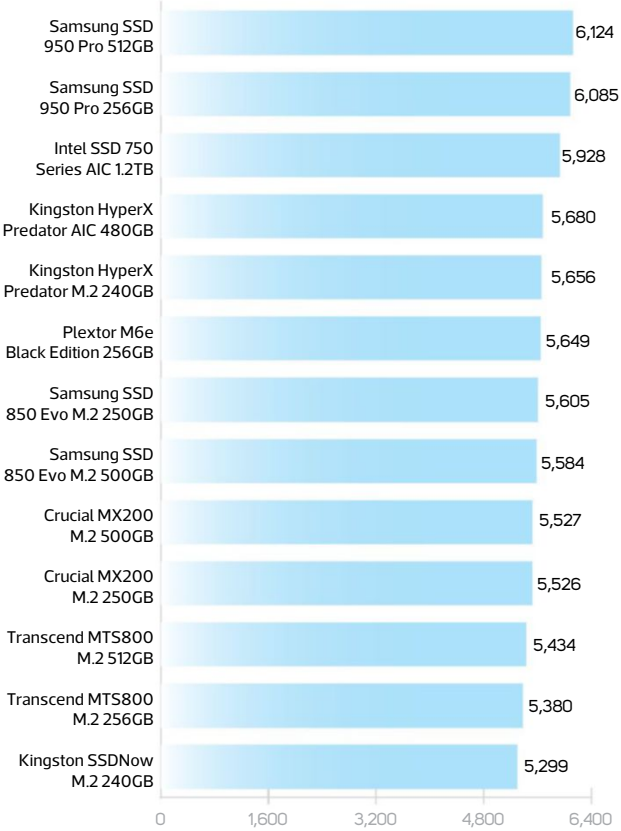
CRYSTALDISKMARK 5.0.2
Random read (MB/sec)



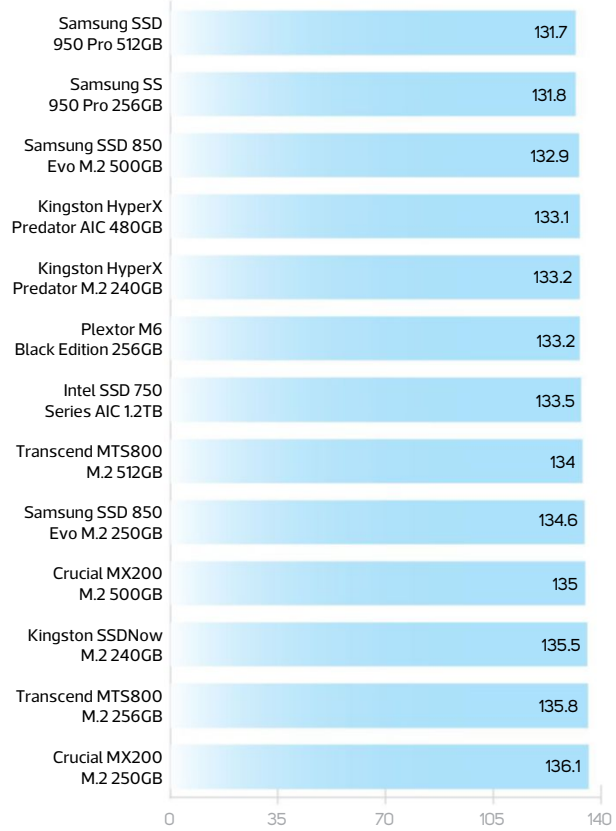
CRYSTALDISKMARK 5.0.2
Random write (MB/sec)



PCMARK 7
Secondary Storage score

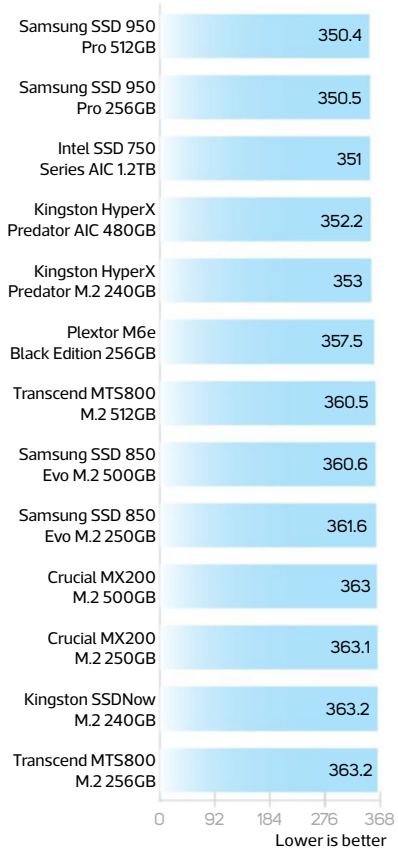


PCMARK 8
Battlefield 3 trace (seconds)

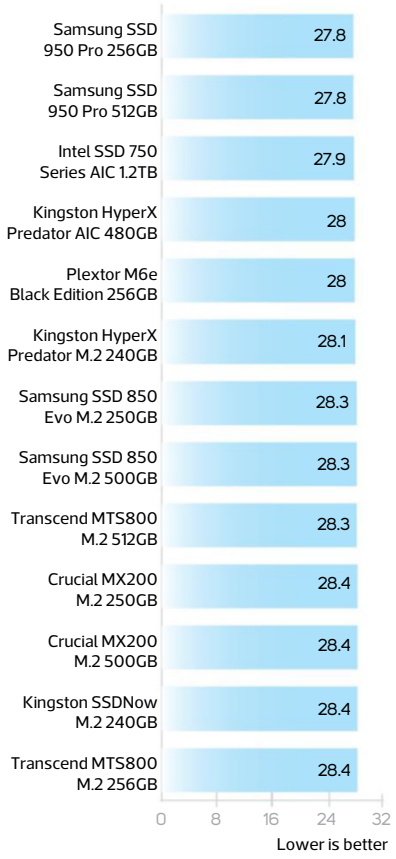


Lower is better

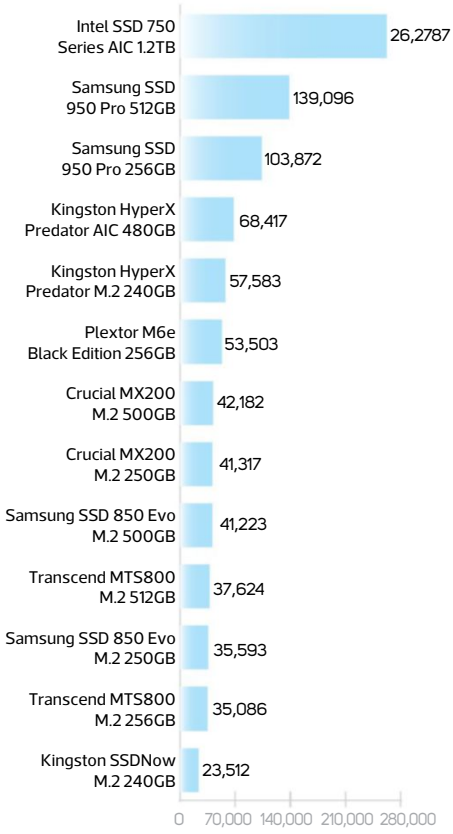
PCMARK 8
Photoshop Heavy trace (seconds)



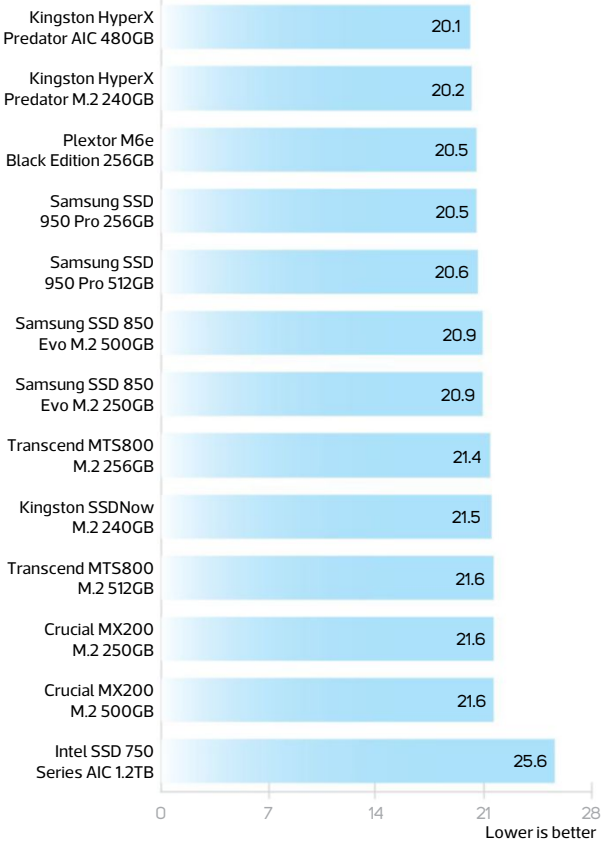
PCMARK 8
Microsoft Word trace (seconds)



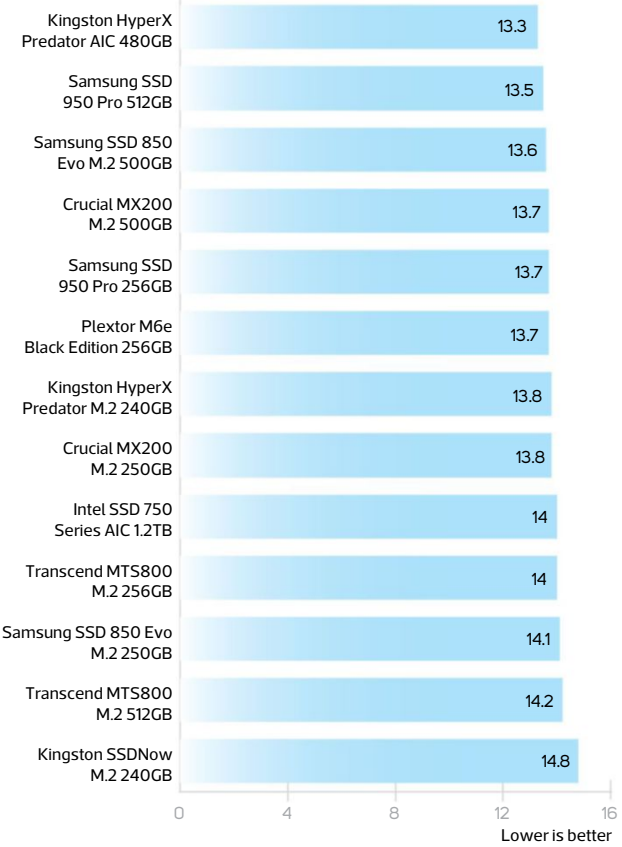
IOMETER
Mixed workloads average (IOPS)



BOOTRACER
Windows 10 64-bit cold boot (seconds)



BOOTRACER
Windows 10 64-bit fast startup (seconds)



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PC system reviews

GAMING PC

PC Specialist Ignis / £1,499 inc VAT

SUPPLIER www.pcspecialist.co.uk

PC Specialist's Ignis stands out with its use of a Parvum case, made from 5mm acrylic rather than metal. There are obvious differences between the Parvum Veer 1.0 and more conventional cases deployed in other mini-ITX chassis. The matt black material throughout is divided by red acrylic that looks especially impressive when it catches sunlight and its smart, layered design is augmented by good-looking touches.

The red layer behind the front panel is visible through a Parvum logo cutout and sleek banded areas, while indents on both sides reveal more red acrylic. Meanwhile, a huge window along one side gives a great view of the components, although it also attracts dust and fingerprints.

The machine is well put together on the inside too. The motherboard sits on a raised section that allows the PSU and its cables to stay hidden, and the GPU and Corsair H100i GTX liquid cooler sit in parallel above the board. It's consistently tidy, which helps show off the red interior panels.

The Parvum chassis looks great, but it also has some downsides. When you lift the system you notice more give in the Parvum's acrylic panels than in most metal cases. The chassis creaks as the plastic rubs, and the material beneath the PSU bends to accommodate the cables. The Ignis never feels weak, but there's no denying that metal feels stronger. The Chillblast Fusion Fury Nano (see Issue 147, p56), for example, uses a smaller Raijintek Metis mini-ITX chassis, which feels sturdier. Like most mini-ITX cases, the Parvum case doesn't excel in the upgrade department either, with just one 2.5in slot spare.

/SPECIFICATIONS

CPU 3.5GHz Intel Core i5-6600K

Motherboard Asus Maximus VIII Impact

Memory 16GB 2133MHz Kingston HyperX Fury DDR4

Graphics Zotac GeForce GTX 980 4GB

Storage 960GB Kingston HyperX Savage SSD

Case Parvum Veer 1.0

Cooling CPU: Corsair Hydro H100i GTX with 2 x 120mm fans; GPU: 1 x 90mm fan

PSU Corsair CS650

Ports Front: 2 x USB 3; rear: 4 x USB 3, 1 x USB 3.1 type-A, 1 x USB 3.1 type-C, 1 x optical S/PDIF, start and reset buttons, Gigabit Ethernet, 3 x audio

Operating system Windows 10 Home 64-bit

Warranty One year parts and labour, plus two years labour only, one month collect and return, then return to base

However, PC Specialist has kitted out the Ignis with an impressive specification. The most potent part is a Zotac GeForce GTX 980. It isn't an overclocked model, but the GPU's 2,048 stream processors and 1,126MHz core clock will make it formidable in games. It's paired with a quad-core Core i5-6600K processor, although its stock speed of 3.5GHz hasn't been overclocked, despite being cooled by a dual-radiator liquid cooler. That's unusual for a machine in **Custom PC**, but it's PC Specialist's choice – we're told the firm doesn't tweak its mini-ITX machines.

Meanwhile, the 16GB of DDR4 RAM is plenty, and the Ignis foregoes platter-based storage for a Kingston HyperX Savage 960GB SSD. That capacity is as large as many hard disks and the drive will beat any hard drive for speed too.

PC Specialist has installed one of the market's best mini-ITX motherboards too. The Asus Maximus VIII Impact sits right at the top of the firm's range of tiny PCBs, and it's impressively feature-packed, with dual-band 802.11ac Wi-Fi and a discrete sound card beneath the rear I/O panel. That rear panel is busy too, with four USB 3 ports alongside USB 3.1 ports in type A and C flavours. The board also sports on-board power and reset buttons, and a dual-figure POST. As with any mini-ITX motherboard, though, there's not much internal upgrade room, with the two memory slots and single 16x PCI-E slot already occupied.

Finally, the PC Specialist's three-year warranty is reasonable, if a little meagre. It has the essential year of parts and labour coverage, plus two years labour only, but there's only a month of collect and return cover before it reverts to a return-to-base deal.

Performance

The Ignis didn't have any trouble with 1080p games, and it played every game at 2,560 x 1,440 without dropping below 35fps. However, it isn't quite capable of 4K gaming, only managing a playable frame rate in Shadow of Mordor.

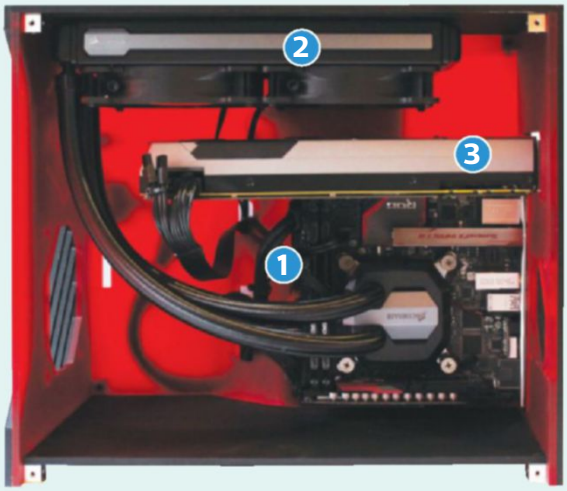
The Ignis fell a little behind in applications, though, because of that stock-speed processor. For example, we've seen an encoding score of 259,334 from an overclocked i5-6600K before, but the Ignis only scored 222,556. It's doubly frustrating when you see the huge liquid-cooling system and know that the CPU's unlocked multiplier would make it capable of so much more.

The stock-speed Core i5 silicon won't be a significant bottleneck in games and it has enough power for most applications, but there's definitely more potential here. There's scope for overclocking the PC Specialist's K-edition processor, at least. We've previously tweaked this part to 4.6GHz and beyond, and the huge Corsair Hydro H100i GTX cooler means there's ample headroom in this PC – the

1 **The PSU hides behind the raised motherboard**

2 **A Corsair H100i GTX liquid cooler is mounted in the roof**

3 **The GTX 980 is great for 2,560 x 1,440 gaming**



CPU's peak delta T of 42°C is low. We didn't have any temperature issues with the GPU either, which topped out with a peak delta T of 57°C. Noise was never an issue either. The Ignis was barely audible when it wasn't running games, and there was only a little low-pitched whir that occasionally modulated up and down in games too.

However, while the PC Specialist's monster Kingston SSD takes a victory for size, it's still limited to SATA speeds, and the motherboard has a U.2 port rather than an M.2 connector (see p42), so upgrading to a super-fast Samsung SSD 950 Pro is off the cards too. The Kingston SSD's AS SSD read and write speeds of 525MB/sec and 492MB/sec are fine, but the aforementioned Chillblast Fury Nano system deployed a Samsung M.2 NVMe drive, which rattled through those same tests at 1,764MB/sec and 1,196MB/sec.

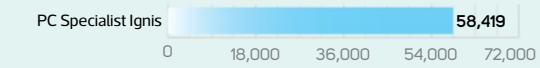
Conclusion

The PC Specialist Ignis' Parvum case looks fantastic and eye-catching, its spec is generally solid and the interior is tidy too. The Ignis suffers, though, when compared with rivals. For example, the Chillblast Fury Nano can be bought for £1,500 with a Core i5-6600K overclocked to 4.4GHz, which will be faster because of its overclocked processor, M.2 SSD and Fury Nano graphics. It might not have the lovely Parvum case, but its Raijintek Metis chassis is sturdier and smaller than the Parvum case. If you're prepared to overclock the CPU yourself, though, and you love the Ignis' looks, it's still a tidy and great-looking machine with plenty of 2,560 x 1,440 gaming power.

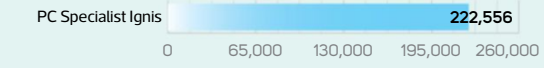
MIKE JENNINGS

CPC REALBENCH 2015

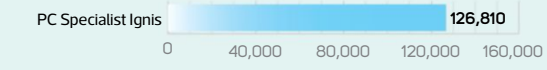
GIMP IMAGE EDITING



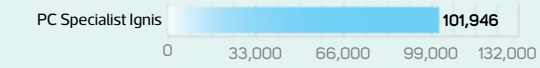
HANDBRAKE H.264 VIDEO ENCODING



HEAVY MULTITASKING

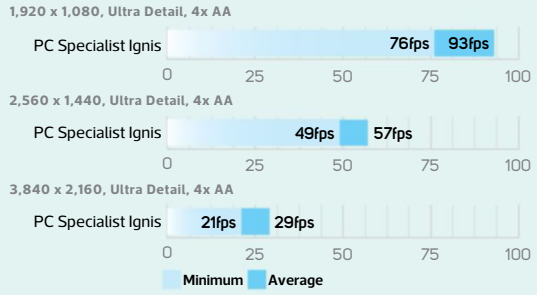


SYSTEM SCORE

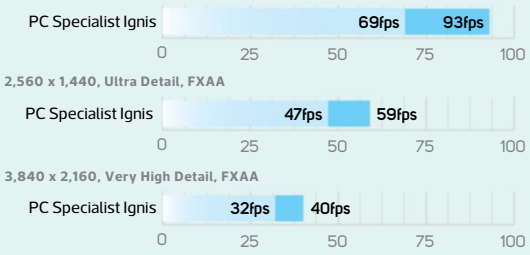


INTEL REFERENCE: 89.07%

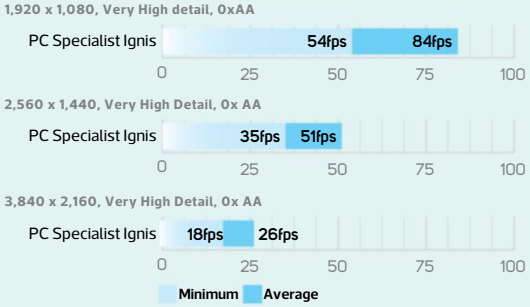
BATTLEFIELD 4



SHADOW OF MORDOR



CRYSIS 3



SPEED	DESIGN	OVERALL SCORE
19/25	23/25	85%
HARDWARE	VALUE	
21/25	22/25	

VERDICT

The Parvum chassis looks fantastic, but the Ignis' lack of a CPU overclock means it can't quite meet its full potential.

GAMING PC

Eclipse i7 Liquid Vengeance / £1,750 inc VAT

SUPPLIER www.eclipsecomputers.com

Corsair's Graphite range of cases is finding favour among loads of enthusiasts and system builders at the moment. Eclipse is the latest firm to deploy the glass-panelled Graphite 760T in its i7 Liquid Vengeance PC, and it's easy to see why. Those swinging glass not only look great, but they're also practical, being much easier to unclip than conventional thumbscrews.

Eclipse has chosen the black version, making the Liquid Vengeance a big, dark, brooding machine, which makes the flashes of red stand out more. The power button is ringed with crimson, the two 140mm fans in the front panel are red, and Eclipse has fitted a pair of red 140mm fans to the Corsair liquid cooler. Even the logo on the Corsair cooler's waterblock/pump unit glows red.

The red and black colour scheme looks excellent, and Eclipse has done a decent job on the inside too. The capacious motherboard tray hides cables, and they're all black, so they're barely visible when they do appear. The interior isn't quite as neat as that of the Scan 3XS Z170 Vengeance, but it's still a clean build. The Asus Strix graphics card, Corsair memory and Asus motherboard are all black and grey too, which makes for an imposing design.

The 760T also offers ample upgrade room. Two cages at the bottom house five spare side-facing hard disk bays with plastic, tool-free cages, and the top of the enclosure has two spare 5.25in bays. There are four 2.5in cages on the rear of the motherboard tray as well. However, the case's size is possibly overkill for such a system. Few people are likely to use nine storage bays these days, and Eclipse hasn't used the extra space to install a bespoke cooling system either. If you have room for it, though, it's great to have the extra airflow space.

Eclipse isn't the only manufacturer to head down this route. The Box Cube Predator (see Issue 147, p58), has a similar specification to the Eclipse inside an even larger Corsair Graphite 780T case. Meanwhile, Scan's 3XS Z170 Vengeance (see Issue 145, p66) uses the Corsair Obsidian 450D, which is only a little smaller.

The Core i7-6700K is Intel's current top Skylake processor, and Eclipse has improved its 4GHz stock speed to 4.5GHz with a 1.35V vcore. Comparatively, the Box ran the same chip at the same speed, while the Scan ran it at 4.6GHz. The Liquid Vengeance also has an Asus Strix GeForce GTX 980, with a good-looking design and a base clock boost from 1126MHz to 1178MHz.

The rest of the Liquid's specification is impressive too. The 16GB of memory runs at 3000MHz, and storage is quick and capacious: the boot drive is a Samsung 950 Pro M.2 SSD (see p48), and the secondary drive is a 2TB hard disk.

Meanwhile, the award-winning Asus Sabertooth Z170 (see p18) looks fantastic. Its expansion slots sit inside Asus' gunmetal grey Thermal Armor, and there are two tiny fans to ensure that components beneath the metal stay cool. It also has five LEDs to indicate parts of the boot process, and switches to control airflow from the tiny fans, although there are no on-board power and reset buttons. The backplate is crammed with features too, including USB 3.1 type A and C ports, a clear-CMOS button and two Gigabit Ethernet ports.

Finally, Eclipse's machine has a three-year warranty with one year of parts coverage and 30 days of collect-and-return service. That's fine, but other firms offer better deals. For example, Scan's warranty with the aforementioned 3XS Z170 Vengeance gives you three years of on-site coverage, including a year of on-site service.

Performance

The Eclipse's overclocked processor means it matches its rivals on paper, but its application benchmark scores makes it a formidable force in our application benchmarks. Its video encoding result of 306,292 is decent, thanks to its four Hyper-Threaded cores, but the higher-clocked Scan system was a little quicker at 326,319. That pattern was repeated in the multi-tasking test too.

Interestingly, the Eclipse only managed a surprisingly low score of 34,078 in our image editing test (which has a knock-on effect on the overall system score), and this result was repeated consistently after several runs.

However, given that we've seen its CPU and motherboard combination manage significantly better results elsewhere, we're going to put this low score down to a software problem of some description that clashes with our benchmarks, rather than the Eclipse being slow, as there was no sign of thermal throttling, and it clearly has plenty of pace in our other tests.

The Liquid Vengeance was fine in games, for example, never dropping below 40fps in any of our 2,560 x 1,440 tests, although it isn't capable of 4K gaming. Comparatively,

/SPECIFICATIONS

CPU 4GHz Intel Core i7-6700K overclocked to 4.5GHz

Motherboard Asus Sabertooth Z170-M1

Memory 16GB Corsair Vengeance LPX 3000MHz DDR4

Graphics Asus GeForce GTX 980 4GB

Storage 256GB Samsung 950 Pro M.2 SSD; 2TB hard disk

Case Corsair Graphite 760T

Cooling CPU: Corsair Hydro H100i GTX with 2 x 140mm fans; GPU: 2 x 100mm fans; front 2 x 140mm fans; rear: 1 x 140mm fan

PSU Corsair CS750 750W

Ports Front: 2 x USB 3, 2 x USB 2, 2 x audio; rear: 2 x USB 3, 1 x USB 3.1 type-A, 1 x USB 3.1 type C, 4 x USB 2, 2 x Gigabit Ethernet, 1 x optical S/PDIF, 5 x audio

Operating system Windows 10 Home 64-bit

Warranty One year parts and labour, plus two years labour only, One month collect and return, then return to base

1 The Sabertooth Z170 features Asus' Thermal Armor

2 The black PSU cables are barely visible

3 There are loads of drive bays, but few people will use them

the aforementioned Box has the upper hand for high-resolution gaming with its GeForce GXT 980 Ti card.

Where the Eclipse's performance shines is in storage. The Samsung SSD 950 Pro's sequential read and write speeds of 1,445MB/sec and 901MB/sec are excellent. The Eclipse's thermal performance was fine too. Its CPU delta T of 66˚C leans towards the hot side, but is within thermal limits, and its GPU delta T of 43˚C is fine. It isn't too noisy, and the sound is consistent, although there is in audible low rumble, making it a little louder than the Box Cube Predator.

Conclusion

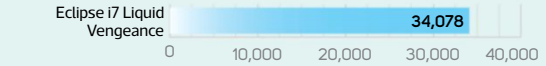
The Eclipse's £1,750 price sits below the aforementioned Scan machines, although prices have naturally changed since the Skylake supply shortage, with Scan's spec as reviewed now coming in at £1,580 inc VAT. The extra money for the Eclipse buys you a larger Corsair liquid cooler, a superior motherboard, more memory and a slightly more powerful PSU, all of which are decent upgrades, and customising the Scan's spec to a similar degree to the Eclipse on Scan's website brings the 3XS Z170 Vengeance into the same price league as the Eclipse, so the Eclipse clearly offers competitive value for money too. However, the Scan still has a superior warranty.

The Eclipse i7 Liquid Vengeance is well built, fast, packed with decent components and has plenty of room to breathe. It isn't quite capable of 4K gaming, but it's a solid 2,560 x 1,440 gaming rig that justifies its £1,750 price tag with a great motherboard, fast SSD, large CPU cooler and loads of RAM.

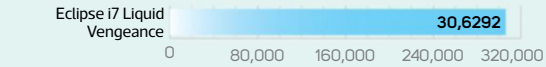
MIKE JENNINGS

CPC REALBENCH 2015

GIMP IMAGE EDITING

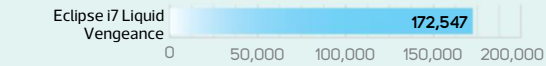


HANDBRAKE H.264 VIDEO ENCODING



LUXMARK OPENCL

HEAVY MULTITASKING

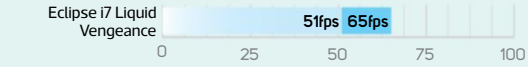


SYSTEM SCORE

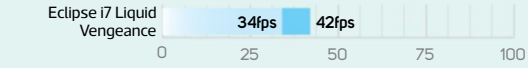
INTEL REFERENCE: 115.3%

SHADOW OF MORDOR

2,560 x 1,440, Ultra Detail, FXAA

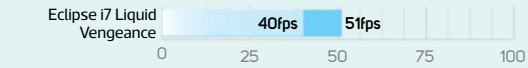


3,840 x 2,160, Very High Detail, FXAA

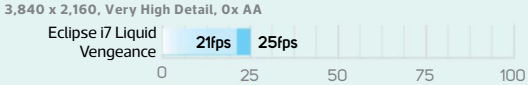


CRYSIS 3

2,560 x 1,440, Very High Detail, 0x AA



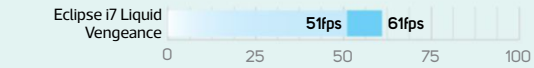
3,840 x 2,160, Very High Detail, 0x AA



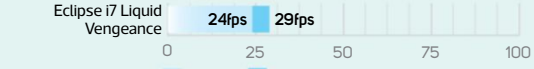
Minimum Average

BATTLEFIELD 4

2,560 x 1,440, Ultra Detail, 4x AA



3,840 x 2,160, Ultra Detail, 4x AA



Minimum Average

SPEED 22/25

DESIGN 21/25

HARDWARE 23/25

VALUE 21/25

OVERALL SCORE 87%

VERDICT

Fast, well built and packed with decent parts, the Liquid Vengeance is a solid 2,560 x 1,440 gaming rig for a reasonable price.

Elite

Our choice of the best hardware available

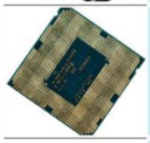
Build a home theatre PC

The parts you'll need to build an affordable, home theatre PC that's ideal for putting in the lounge and playing back all manner of video formats. This machine will handle general computing and media tasks with no trouble, and its dual-core Skylake CPU can even handle 4K video playback. Meanwhile, its super-quiet Noctua CPU cooler prevents it from making a racket.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Lian Li PC-Q09FNB with 300W FSP SFX PSU	www.overclockers.co.uk	Issue 149, p92	£110
	Intel Core i3-6100T	www.overclockers.co.uk	Issue 149, p92	£96
	Asus H110i-Plus (DDR4 version)	www.scan.co.uk	Issue 149, p92	£60
	8GB Corsair 2133MHz Vengeance DDR4	www.ebuyer.com	Issue 149, p92	£43
	Noctua L9i	www.scan.co.uk	Issue 149, p93	£33
	Samsung SN-208FB	www.amazon.co.uk	Issue 149, p93	£14
	Seagate Barracuda 2TB	www.ebuyer.com	Issue 149, p93	£57
	Crucial 256GB BX100	www.ebuyer.com	Issue 149, p93	£66
	Logitech K400 Plus	www.dabs.com	Issue 149, p93	£31
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	**£598**

Build a budget gaming PC

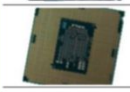
The parts you'll need to build a budget machine capable of playing the latest games at maximum settings on a 1080p monitor, and even some games at 2,560 x 1,440. The machine has a discrete graphics card, a highly overclockable dual-core CPU and high-speed memory. Meanwhile, the Z97 motherboard gives you headroom to upgrade to a faster CPU later.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	ASRock Z97 Pro3	www.scan.co.uk	Issue 130, p50	£71
	Intel Pentium G3258	www.scan.co.uk	Issue 132, p17	£53
	8GB Corsair Vengeance Pro 2400MHz DDR3 (CMY8GX3M2A2400C11R)	www.scan.co.uk	Issue 132, p22	£42
	AMD Radeon R9 380 2GB	www.overclockers.co.uk	Issue 148, p44	£150
	250GB Crucial BX100	www.ebuyer.com	Issue 144, p84	£66
	SilverStone Argon AR01	www.scan.co.uk	Issue 132, p57	£26
	EVGA SuperNova GS 550W	www.scan.co.uk	Issue 146, p50	£65
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£53
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£674

Build a mid-range PC

Work PC

The parts you'll need to build a solid quad-core PC with plenty of upgrade potential. This kit list gives you an all-in-one liquid cooler and a K-series Core i5 Skylake CPU, meaning you can overclock it and get some serious processing power. We've managed to get the Core i5-6600K Skylake CPU up to 4.6GHz, so it has some great performance potential. Also included is a solid EVGA PSU, a 500GB SSD and 8GB of high-speed DDR4 memory. The core configuration assumes you won't be doing any serious gaming, however, and it relies on Intel's integrated graphics.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	Asus Maximus VIII Ranger	www.scan.co.uk	Issue 147, p44	£139
	Intel Core i5-6600K	www.scan.co.uk	Issue 145, p17	£195
	8GB Corsair Vengeance LLPX 2666MHz DDR4 (CMK8GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£46
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£75
	EVGA SuperNova GS 550W	www.scan.co.uk	Issue 146, p50	£65
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£53
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£9
	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£126
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	**£894**

Gaming PC

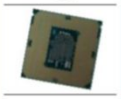
The graphics card you'll need to play current games at their maximum settings at 1080p and 2,560 x 1,440.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 x 1,080** AMD Radeon R9 380 2GB	www.overclockers.co.uk	Issue 148, p44	£150
	**2,560 x 1,440** Nvidia GeForce GTX 970 4GB	www.overclockers.co.uk	Issue 148, p47	£240

Build a performance PC

Work PC

The parts you'll need to build a high-quality, fast PC that's ideal for multi-threaded workloads. This kit list features a high-quality, well-built case, a feature-rich motherboard and an Intel Skylake Core i7-6700K CPU. This processor's support for Hyper-Threading splits the resources of the CPU's four physical cores into a further four virtual cores, meaning it can effectively handle eight threads at once. There's also a solid Corsair 750W PSU, giving you plenty of headroom for overclocking and adding another GPU, 16GB of DDR4 memory, a high-speed M.2 SSD and an all-in-one liquid cooler.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£137
	Asus Maximus VIII Hero	www.overclockers.co.uk	Issue 146, p20	£170
	Intel Core i7-6700K	www.scan.co.uk	Issue 145, p17	£339
	16GB Corsair Vengeance LLPX 2666MHz DDR4 (CMK16GX4M2A2666C16)	www.scan.co.uk	Issue 145, p24	£83
	NZXT Kraken X41	www.overclockers.co.uk	Issue 138, p57	£75
	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£104
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£53
	Samsung SSD 950 Pro 256GB	www.ebuyer.com	Issue 149, p48	£147
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	**£1,196**

Gaming PC

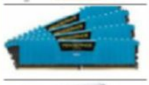
The graphics card you'll need to play current games at their maximum settings at 2,560 x 1,440 and beyond.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**2,560 x 1,440** Nvidia GeForce GTX 970 4GB	www.overclockers.co.uk	Issue 148, p47	£240
	**4K** 2 x Nvidia GeForce GTX 970 4GB	www.overclockers.co.uk	Issue 140, p50	£480

Build a high-end 6-core PC

Multi-threaded PC

The parts you'll need to build a PC with serious power in multi-threaded software, such as 3D rendering apps, video editing programs and optimised distributed computing software. The kit list features a 6-core LGA2011-v3 CPU, which is overclockable using the motherboard and top-end cooler listed. Also supplied is 16GB of RAM, a super-fast M.2 SSD, 1TB of extra solid state storage and a 1.2kW PSU, providing loads of headroom for adding multiple GPUs.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	Asus X99 Deluxe	www.overclockers.co.uk	Issue 136, p20	£315
	Intel Core i7-5820K	www.scan.co.uk	Issue 134, p43	£309
	AMD Radeon R9 380 2GB	www.overclockers.co.uk	Issue 148, p44	£150
	16GB Corsair Vengeance LPX 2666MHz DDR4 (CMK16GX4M4A2666C16)	www.scan.co.uk	Issue 136, p14	£90
	EKWB EK-Predator 240	www.scan.co.uk	Issue 148, p30	£163
	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£260
	Samsung SSD 950 Pro 512GB	www.dabs.com	Issue 149, p48	£261
	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£268
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£9
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88
			TOTAL	£2,030

4K gaming PC

This LGA2011-v3 system can support multiple graphics cards over 28 PCI-E 3 lanes, making it an ideal foundation for high-resolution PC gaming, replacing the graphics card listed above with two high-spec cards.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**4K** 2 x Nvidia GeForce GTX 970 4GB	www.overclockers.co.uk	Issue 140, p50	£480
			TOTAL	£2,360

Build a mini PC

Core components

The parts you'll need to build either PC. This kit list gives you a solid PSU, 16GB of RAM, an overclockable Skylake CPU, an all-in-one liquid cooler and Windows 10 Home 64-bit. Also included is a short-PCB graphics card that can play current games at their maximum settings at 2,560 x 1,440, and a high-speed 256GB M.2 SSD.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Intel Core i7-6700K	www.scan.co.uk	Issue 147, p84	£339
	16GB (2 x 8GB) Corsair Vengeance LPX 2666MHz	www.scan.co.uk	Issue 147, p84	£83
	Corsair H80i GT	www.scan.co.uk	Issue 147, p84	£80
	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£270
	Samsung SSD 950 Pro 256GB	www.ebuyer.com	Issue 149, p48	£147
	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£53
	Lite-On IHAS124-14	www.dabs.com	Issue 99, p108	£9
	EVGA SuperNova GS 550W	www.scan.co.uk	Issue 146, p50	£65
	Microsoft Windows 10 Home Retail USB drive	www.scan.co.uk	Issue 146, p17	£88

Mini-ITX PC

The parts you'll need to build a pint-sized powerhouse.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£75
	Asus Z170i Pro Gaming	www.cclonline.com	Issue 147, p26	£124
			TOTAL	£1,333

Micro-ATX PC

The parts you'll need to build a mini PC that doesn't take up as much room as a full-sized desktop.

	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£67
	Asus Maximus VIII Gene	www.eclipsecomputers.com	Issue 147, p42	£168
			TOTAL	£1,369

Cases

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Budget ATX**	NZXT S340	www.overclockers.co.uk	Issue 137, p54	£60
	**Sub-£100 ATX quiet**	Fractal Design Define R5	www.scan.co.uk	Issue 137, p20	£80
	**Sub-£100 ATX performance**	NZXT Phantom 530	www.overclockers.co.uk	Issue 127, p44	£98
	**Sub-£150 full-sized ATX quiet**	Nanoxia Deep Silence 5	www.quietpc.com	Issue 144, p50	£113
	**Sub-£150 full-sized ATX**	Phanteks Enthoo Luxe	www.eclipsecomputers.com	Issue 144, p53	£117
	**Sub-£150 mid-size ATX**	Cooler Master Cosmos SE	www.cclonline.com	Issue 144, p41	£137
	**Mini-ITX tower**	Corsair Obsidian 250D	www.scan.co.uk	Issue 136, p41	£75
	**Mini-ITX cube**	Antec ISK600	www.overclockers.co.uk	Issue 126, p28	£45
	**Micro-ATX**	Fractal Design Arc Mini R2	www.scan.co.uk	Issue 127, p46	£67
	**Water-cooling micro-ATX**	Parvum Systems S2.0	www.overclockers.co.uk	Issue 129, p22	£140

Graphics cards

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**1,920 x 1,080 gaming**	AMD Radeon R9 380 2GB	www.overclockers.co.uk	Issue 148, p44	£150
	**2,560 x 1,440 gaming**	Nvidia GeForce GTX 970 4GB	www.overclockers.co.uk	Issue 148, p47	£240
	**High-end single-GPU gaming**	EVGA GeForce GTX 980 Ti Classified ACX 2.0+	www.scan.co.uk	Issue 147, p24	£588
	**4K gaming**	2 x Nvidia GeForce GTX 970 4GB	www.overclockers.co.uk	Issue 140, p49	£480
	**Mini-ITX**	Asus GeForce GTX 970 DirectCU Mini	www.overclockers.co.uk	Issue 139, p20	£276

Power supplies

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Mid-range 550W**	EVGA SuperNova GS 550W	www.scan.co.uk	Issue 146, p50	£65
	**High-end 550W**	Super Flower Leadex Platinum 550W	www.overclockers.co.uk	Issue 146, p52	£88
	**Mid-range 750W**	Corsair RM750i	www.scan.co.uk	Issue 146, p55	£104
	**High-end 1.2kW**	Corsair Professional Series AX1200i	www.scan.co.uk	Issue 111, p40	£260

Networking

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Router**	Asus RT-AC68U	www.scan.co.uk	Issue 128, p88	£148
	**Wi-Fi adaptor**	Asus PCE-AC68	www.scan.co.uk	Issue 128, p88	£67

Storage

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Hard disk**	Seagate Barracuda 2TB ST2000DM001	www.scan.co.uk	Issue 104, p75	£53
	**250GB SSD**	Crucial BX100 250GB	www.ebuyer.com	Issue 141, p43	£66
	**500GB SSD**	Crucial BX100 500GB	www.ebuyer.com	Issue 141, p43	£126
	**1TB SSD**	Samsung 850 Evo 1TB	www.cclonline.com	Issue 141, p51	£268
	**High-performance SSD**	Samsung SSD 950 Pro 512GB	www.dabs.com	Issue 149, p48	£261
	**NAS box**	Synology DS215J	www.cclonline.com	Issue 138, p17	£134

Monitors

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**24in monitor**	Dell U2414H	www.overclockers.co.uk	Issue 129, p43	£186
	**29in monitor**	Asus PB298Q	www.scan.co.uk	Issue 129, p52	£285
	**28in 4K monitor**	Asus PB287Q	www.scan.co.uk	Issue 133, p44	£380
	**G-Sync monitor**	Asus ROG Swift PG278Q	www.eclipsecomputers.com	Issue 143, p44	£552
	**FreeSync monitor**	BenQ XL2730Z	www.overclockers.co.uk	Issue 143, p46	£396
	**4K G-Sync monitor**	Asus ROG Swift PG27AQ UPDATED	www.scan.co.uk	Issue 149, p24	£750

Peripherals

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Mechanical gaming keyboard**	CM Storm Trigger-Z	www.eclipsecomputers.com	Issue 139, p44	£95
	**Mechanical MMO keyboard**	Corsair Vengeance K95	www.awd-it.co.uk	Issue 123, p64	£125
	**Budget gaming mouse**	Cooler Master Xornet II UPDATED	www.cclonline.com	Issue 149, p28	£20
	**Gaming mouse**	Logitech G402 Hyperion Fury	www.currys.co.uk	Issue 139, p53	£40
	**Wireless gaming mouse**	SteelSeries Sensei Wireless	www.box.co.uk	Issue 139, p61	£100
	**Flight stick**	Saitek X-55 Rhino H.O.T.A.S.	www.overclockers.co.uk	Issue 131, p29	£120
	**Steering wheel and pedals**	Thrustmaster TX Ferrari 458 Italia Edition	www.overclockers.co.uk	Issue 137, p32	£265

Audio

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**PCI-E sound card**	Asus Strix Raid DLX	www.cclonline.com	Issue 148, p28	£141
	**USB DAC**	Asus Xonar Essence One	www.overclockers.co.uk	Issue 118, p44	£363
	**2.1 speakers**	Acoustic Energy Aego M	www.amazon.co.uk	Issue 142, p52	£160
	**Soundbar**	Razer Leviathan	www.overclockers.co.uk	Issue 142, p57	£165
	**Headset**	HyperX Cloud II	www.scan.co.uk	Issue 142, p46	£69
	**Surround-sound headset**	Asus Strix 7.1	www.cclonline.com	Issue 142, p43	£133

Systems

	TYPE	NAME	SUPPLIER	FEATURED	PRICE (inc VAT)
	**Quiet gaming PC**	Chillblast Fusion Serenity	www.chillblast.co.uk	Issue 138, p66	c. £1,499
	**Dream PC**	Scan 3XS Barracuda	www.scan.co.uk	Issue 145, p58	c.£9,499
	**Sub-£2,000 gaming PC**	Scan 3XS X99 Carbon Ti	www.scan.co.uk	Issue 143, p58	c.£1,999
	**Skylake PC**	Scan 3XS Z170 Vengeance	www.scan.co.uk	Issue 145, p66	c. £1,449
	**Mini-ITX gaming PC**	Chillblast Fusion Fury Nano	www.chillblast.co.uk	Issue 147, p56	c.£1,619
	**Gaming laptop**	MSI GT70 2PC Dominator	www.overclockers.co.uk	Issue 129, p26	c. £1,320
	**Premium PC**	Scan 3XS X99 Carbon Extreme SLI	www.scan.co.uk	Issue 148, p62	c.£4,799

Games

Featured this month

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Warhammer: The End Times: Vermintide p76 / The engine room – Avalanche p78 /
Custom PC makes a video game - part five p80

RICK LANE / INVERSE LOOK

MOTION BLEURGH

Creating beautiful games is about more than cramming in gratuitous graphical effects, argues Rick Lane

For every game review I write for **Custom PC**, I take somewhere between 250 and 1,000 screenshots to use as accompanying images. The reason I take so many is because the vast majority end up being unusable. Characters or enemies aren't fully in shot, or the action is obscured by objective markers or a dazzling explosion effect. Or, as is most often the case, the image is simply horribly blurred. This latter problem comes courtesy of the wonderful graphical effect that is motion-blur, one of the silliest aesthetic conventions in modern gaming.

For those of you unfamiliar with the technique, motion-blur is a post-process effect used to blur the image on screen when the player turns or tilts the game camera, most often to simulate the effect of your eyes refocusing when you turn your head. It's a bizarre implementation; this effect only occurs if you spin around with enough force to rattle your brain inside your skull like a rugby ball in a tumble dryer, in which case blurred vision is probably the least of your concerns.

Smudging out the world like an inkblot whenever the player moves completely defeats the point of artists creating the lovingly rendered environments that are a staple in today's games. For years, the mainstream game industry has tried to cram more and more polygons into real-time graphics to render crisp, detailed images. But then a motion-blur effect gets slapped in front of it, like the work of a frazzled teacher doing the make-up for a school nativity play.

Motion-blur isn't the only offender in the line-up of bad graphical effects. A few years back, Bloom lighting was the worst culprit, saturating games such as Fable and the recent Syndicate reboot, making them appear as if they were half-immersed in the sun.

A lot of poorly thought-out graphical effects emerge from games treating the game camera like an actual video camera, rather than the perspective from which the player sees the game. It results in bizarre visual frippery, such as water and dirt splashing directly onto the screen as if it was a lens, as well as lens flare, film grain and most recently chromatic aberration. The latter occurs when a lens can't unify all the colour wavelengths in the same focal plane, causing a blurry, coloured 'fringe' to appear around the image's focus. So not only are game cameras simulating lenses, they're simulating *bad* lenses as well.

> Not only are game cameras simulating lenses, they're simulating *bad* lenses as well

These techniques aren't entirely without their place. It's sensible to use effects such as film grain and chromatic aberration in Alien: Isolation. Here, the developer painstakingly recreated the look of Alien, a film made in 1979.

The problem is that many of these effects are included as standard in visual post-processing, part of a frustrating tendency among larger devs and publishers to cram as many graphical effects into a game as possible, instead of considering what best suits the game stylistically. It's lazy showboating, and it's increasingly counterproductive because these newer effects are only noticeable when they're ramped up to the point of being visually obstructive.

Computer graphics are now good enough to accommodate many different aesthetic styles, and it's time for developers to start putting greater thought into *how* they want to reflect their systems, themes and motifs visually, rather than treating graphics as a numbers game. If your approach is simply to mix every colour, you'll always end up with brown. CPC

Rick Lane is Custom PC's games editor. @Rick_Lane

Fallout 4 / £40 inc VAT

DEVELOPER Bethesda Game Studios / **PUBLISHER** Bethesda Softworks / **WEBSITE** www.fallout4.com

Bethesda Softworks' games are undeniably magical. The Elder Scrolls series and rebooted Fallout sequels embrace the 'go anywhere, do anything' motto of sandbox gaming like no other games, with astonishingly realised open worlds and the promise of new surprises around every corner, which makes it easy to dismiss their shortcomings. Fallout 4 retains that seductive power. Its world is vast, beautiful and abundant with adventure.

In a slight twist on the usual formula, Fallout 4 begins minutes before the bombs fall. You create your character using a brilliantly designed set of sculpting tools, and spend a precious few minutes enjoying the peaceful idyll of post-scarcity Americana. Within minutes, however, a terrifying news bulletin sends you and your family racing towards the nearest Fallout shelter – Vault 111. Your character emerges years later into a radically changed world, and begins the search for their son, Shaun, who was kidnapped when the Vault first reopened.

As ever, Bethesda's environment design is stunning. Fallout 4's wasteland is far more detailed and vibrant than that seen in Fallout 3. The skies are bright blue rather than sickly sepia, and the patchwork skyscrapers of post-nuclear Boston gleam a dozen different shades in the midday sun. It's eerily beautiful, but the wreckage of humanity is a constant reminder of this new world's hostility too. Centuries-old skeletons litter streets and buildings, the roads are shattered shards of tarmac playing home to rusting cars. Many of the buildings you pass are little more than hollowed-out shells filled with debris, and those you can enter are cluttered with pre-war junk that's long since lost its purpose.

Centuries-old skeletons litter streets and buildings

The central storyline takes you from the woodland suburbs of the Massachusetts Commonwealth deep into the heart of irradiated Boston, and revolves around the search for the mysterious Institute, which terrorises the local populace by infiltrating human-like Synth robots into society, and is the prime suspect in your son's disappearance. As always with Bethesda's games, however, Fallout 4 is really about exploring freely and taking on whatever missions suit you, be it helping out the Brotherhood of Steel fend off Feral Ghouls and bandit Raiders at the Cambridge police station, taking on missing person cases at the Valentine Detective Agency, or investigating strange goings-on at the Salem Museum of Witchcraft. There's no shortage of activities to occupy your time.

The mission structure is buoyed by a more streamlined dialogue system, with a fully voiced main character, and writing that's stronger than that of Bethesda's previous effort, Skyrim. It still doesn't carry the emotional heft of BioWare's games or The Witcher 3, which is a shame, given that the thrust of the plot is that you're searching for your missing baby boy. However, it's definitely more characterful than before – detective Nick Valentine and dogged, fiery journalist Piper are two particular highlights.

Whatever goals you pursue in Fallout 4, achieving them will likely involve fighting at some point, and the emphasis on combat is noticeably greater than in previous Bethesda titles. You'll rarely go more than a few minutes without something trying to kill you. To a certain degree, this focus makes sense; Fallout 4's Commonwealth is inhospitable by its very nature. However, the combat system, albeit improved through slicker animations and an extra injection of pace, still becomes repetitive simply due to how often you need to use it.

The combat focus also means many of the potentially more interesting approaches to the game have to be neglected by necessity. Stealth is rendered all but useless – usually, the only way around an enemy is through it, and resolving conflict through dialogue is an option that's sparingly offered. Moreover, the levelling system is fairly stingy in its rewards, meaning that many of the more interesting perks have to be ignored in favour of improving your combat prowess. This compromise between a stats-based RPG and a twitch-based FPS means Fallout 4 fails to truly satisfy in either category.

This problem of trying to include features that lack strong foundations is present elsewhere too. Fallout 4 doesn't want you to travel the wastes alone, and includes a dozen possible companions to accompany you on your adventures. The standard companion is Dogmeat, a friendly German shepherd who can sniff out goodies amid the wreckage of the waste, and pin down enemies during combat. He's good company, and useful when acting on his own initiative. However, actually interacting with him is a pain, as you can only issue commands when up close and standing still. Companions also have a tendency to get lost or stuck because of the complex landscape geometry, and if you want to switch one for another, you have to seek them out in the world first, which quickly feels like unnecessary busywork.

Lastly, Fallout 4 introduces an extensive crafting system that lets you build workstations, houses and entire settlements in certain areas. These ramshackle villages attract settlers, and you can even establish trade routes between them. It's a neat idea, but in practice, it's a bit like dropping a Lego set on a Dungeons and Dragons game – the two don't feel organically connected. It doesn't help that the interface is clunky and there's a lot of information that the game simply doesn't communicate, such as how to assign work details to settlers.

Ultimately, the crafting systems smacks of desperation to introduce a new idea in a game that uses a formula largely unchanged since 2003's Morrowind. The sad thing is that there's actually nothing wrong with the Bethesda formula, except that its components require considerable refinement. It needs either exceptional combat or the proper accommodation of alternative play styles, and a dedicated system for managing and commanding companions. Fallout 4 remains broadly enjoyable, with a stunning open world and environment, but it feels like Bethesda is resting on its laurels.

RICK LANE

OVERALL SCORE
75%

/ VERDICT
Bethesda provides another huge and beautiful world to explore, but it's marred by a focus on repetitive combat and new features that lack strong foundations.


POWER NOODLES
HP
E


GUNNER
CRIT
[Space] EXECUTE CRITICAL


RADROACH
CRIT
EXECUTE CRITICAL
Tab) ABORT


MIRELURK KILLCLAW
CRIT
[Space] EXECUTE CRITICAL
Tab) ABORT


INN


FERAL GHOUL

Anno 2205 / £50 inc VAT

DEVELOPER Ubisoft Blue Byte / **PUBLISHER** Ubisoft / **WEBSITE** http://tinyurl.com/UbisoftAnno

OVERALL SCORE 70%

/ VERDICT
Beautiful and cleverly layered, but Anno 2205 is held back by asinine side activities and an inability to shut its mouth.

In what's possibly the perfect game premise, Anno 2205 is about building a city on the moon. Taking place in the 23rd century, where cities are built and governed by benevolent, carbon-neutral corporations, Anno places you in the penthouse office of one such unlikely capitalist venture. You're then tasked with becoming the world's number one business, by constructing and supporting a lunar colony, and plundering its abundant mineral wealth.

Not surprisingly, building a city on the Moon is expensive, so you must first establish yourself on Earth by founding at least two other metropolises – the first in an idyllic, resource-rich temperate zone; the other in the Arctic, where settlements must be constructed close to heat sources and your business activities must remain environmentally conscious.

What makes Anno 2205 interesting is its complex blend of city building and resource management. Each of the three city types has multiple classes of individuals, from lowly workers to high-flying executives, and each of these socio-economic layers needs to be supported by the one below it. In addition, each zone produces unique items from a chain of

resources, some of which are required by other zones. It all results in an intricate web of trade routes and product chains that's gently satisfying to string together.

The satisfaction is compounded by the delightful detail. Tiny robots tend to crops, flying cars zip between skyscraper-lined streets and, on the moon, tiny astronauts hop and skip between your colony buildings.

Around the time you begin constructing your moon colony, however, problems begin to emerge. Supporting your moon base requires a significant cash flow, which means having a huge workforce on Earth; this in turn means supporting that workforce's needs through expanded

Star Wars: Battlefront / £50 inc VAT

DEVELOPER EA DICE / **PUBLISHER** EA / **WEBSITE** www.ea.com/starwarsbattlefront

OVERALL SCORE 60%

/ VERDICT
Like the Galactic Empire, Star Wars: Battlefront makes an impressive display of power, but beyond its spectacle lies a disappointingly hollow experience.

Star Wars: Battlefront is the closest you'll currently get to the gaming equivalent of a popcorn movie. It's a simple and immediately accessible multiplayer shooter that dispenses with depth or tactical nuance in favour of dazzling spectacle.

Battlefront allows you to play as a Rebel Alliance soldier or an Imperial Stormtrooper in a wide variety of game modes, battling in classic locales from the Star Wars universe. The two headlines acts are Supremacy, where players vie for control over key tactical locations on the map, and Walker Assault, in which the Rebels must destroy two hulking AT-AT Walkers encroaching on their base, while the Imperials must defend the walkers until they reach their target.

These 40-player Star Wars battles are astonishing experiences. DICE's latest iteration of the Frostbyte engine renders the Star Wars universe with remarkable clarity and detail. But what really makes it special is the sound. The pin-sharp laser blasts, the scream of encroaching TIE fighters and the muffled cries of Stormtroopers are blended with DICE's incredible flair for explosions and concussions, resulting in the best-sounding game of the year.

Battlefront's greatest triumph, though, is how it surrounds you with the Star Wars universe, from the terrifying battle of




supply chains. There's no way to automate any of these early-game processes. Consequently, the more you expand, the more micromanaging is necessary.

There isn't much strategy involved in building your cities either. You basically construct it all in a fairly strict order, leaving little room for creativity. Blue Byte attempts to add variety in the form of optional side missions and combat scenarios, but both have all the depth of Saturday night television. Worst of all, despite most of these missions being optional, the game reminds you about them constantly like a fussy parent. 'Have you expanded your Navy? Have you fended off that rebel incursion? Have you tidied your bedroom?' It's absolutely infuriating.

If you can put up with a game that nags you to do busywork that's less interesting than its own core systems, there's a pleasing city builder hidden in Anno 2205. Given that Cities: Skylines is far less bothersome and costs half the price, however, Blue Byte's latest game is difficult to recommend wholeheartedly.

RICK LANE

Hoth, where both sides flood each other with laser fire as the towering AT-ATs creep ever closer, to the chaos of fighting on Endor, where the verdant forest foliage and mazelike treetop villages break down each battle into disorienting clusters of skirmishes.

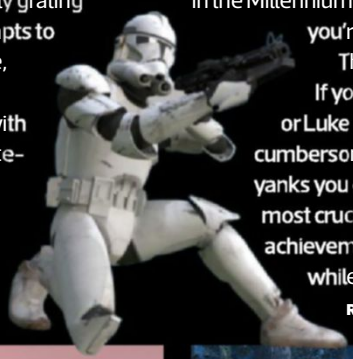
While the game modes are plentiful, though, the number of available maps is tiny, which is particularly grating given the price tag and EA's unsubtle attempts to sell you downloadable content. Meanwhile, the actual shooting is rudimentary at best. Nearly all the main weapons are blasters with slightly varying rates of fire, and the distance-headshot nature of Battlefield's combat doesn't sit comfortably in Battlefront's simplified combat model.

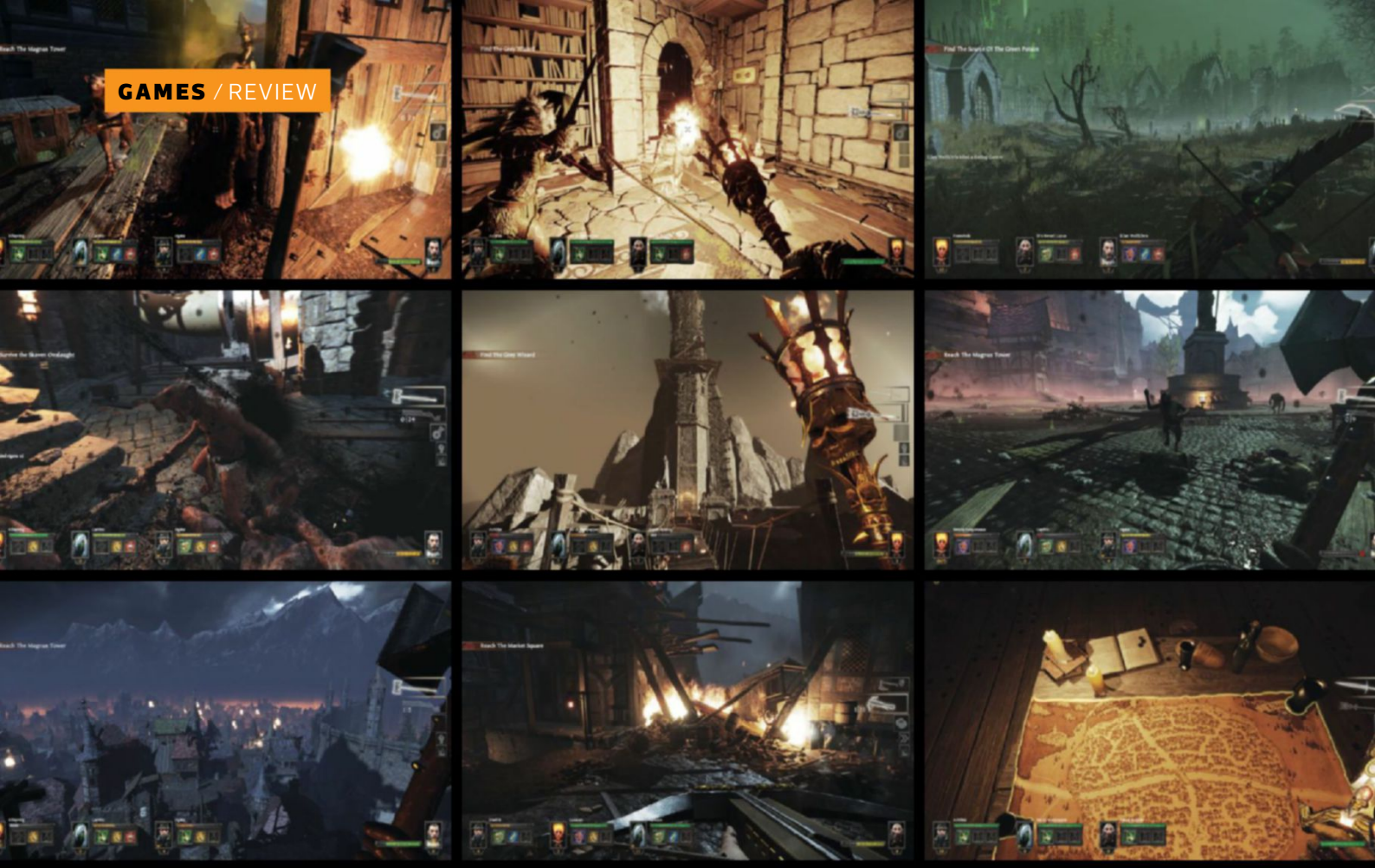
As a result, smaller modes such as the deathmatch-esque Blast, and capture-and-hold variants Droid Run and Drop Zone, struggled to retain our attention.

Many aspects of the game simply aren't well designed either. The larger battles let you pilot airborne vehicles, X-Wings, TIE Fighters and so on, but their controls are absolutely dreadful. If you can go longer than 30 seconds in the Millennium Falcon without plummeting like a dart, you're probably a better pilot than Han Solo.

The 'heroes' are clumsily implemented too. If you're lucky enough to play as Darth Vader or Luke Skywalker, the game switches to a cumbersome over-the-shoulder perspective, which yanks you out of the immersion at the point where it's most crucial. Battlefront is a tremendous technical achievement, and will satisfy Star Wars fans for a while, but it will only entertain you for so long.

RICK LANE





Warhammer: The End Times: Vermintide / £23 inc VAT

DEVELOPER Fatshark / **PUBLISHER** Games Workshop / **WEBSITE** www.vermintide.com

Imitation is allegedly the sincerest form of flattery, but if someone copied almost everything we did while dressed in a giant rat costume, it probably wouldn't be particularly endearing. Such is the case with Warhammer: The End Times: Vermintide, a game that doesn't so much borrow the structure and systems of Left 4 Dead as claim squatters' rights to them.

Set in the classic Warhammer universe – specifically the gothic city of Ubersreik – it teams you up with three other players, tasking you with fending off hordes of rodent-like Skaven as you navigate the city's twisting streets, completing various objectives to hold back the eponymous Vermintide. To survive, you must work together, watching each other's backs as you hack and shoot your way through the Skaven. A game is lost if all four players are incapacitated.

The similarities between Vermintide and Left 4 Dead are many and specific. Controlling Vermintide's action is an AI director, which determines where and when enemies spawn. Sometimes it triggers swarms of Skaven that attempt to overwhelm you through sheer numbers. At other times, it dispatches a range of specialised Skaven such as the Ratling Gunner, who suppresses your team with heavy machine-gun fire, or the Packmaster, who grabs unsuspecting players with a choking snare before dragging them into a corner to hang them on a pole. Alongside their two weapons, players can use healing items and throw explosives. Missions then conclude with a survival sequence in which players battle a particularly large horde of Skaven, before rushing to a nearby cart to escape.

The extent of Vermintide's copycatting is frankly vulgar, although there are a few differences. For example, your chosen character affects your available loadout – some characters emphasise two-handed weapons, while others are happier with a one-handed weapon and a shield. New weapons and items can also be unlocked by performing well, adding a sense of progression to the proceedings.

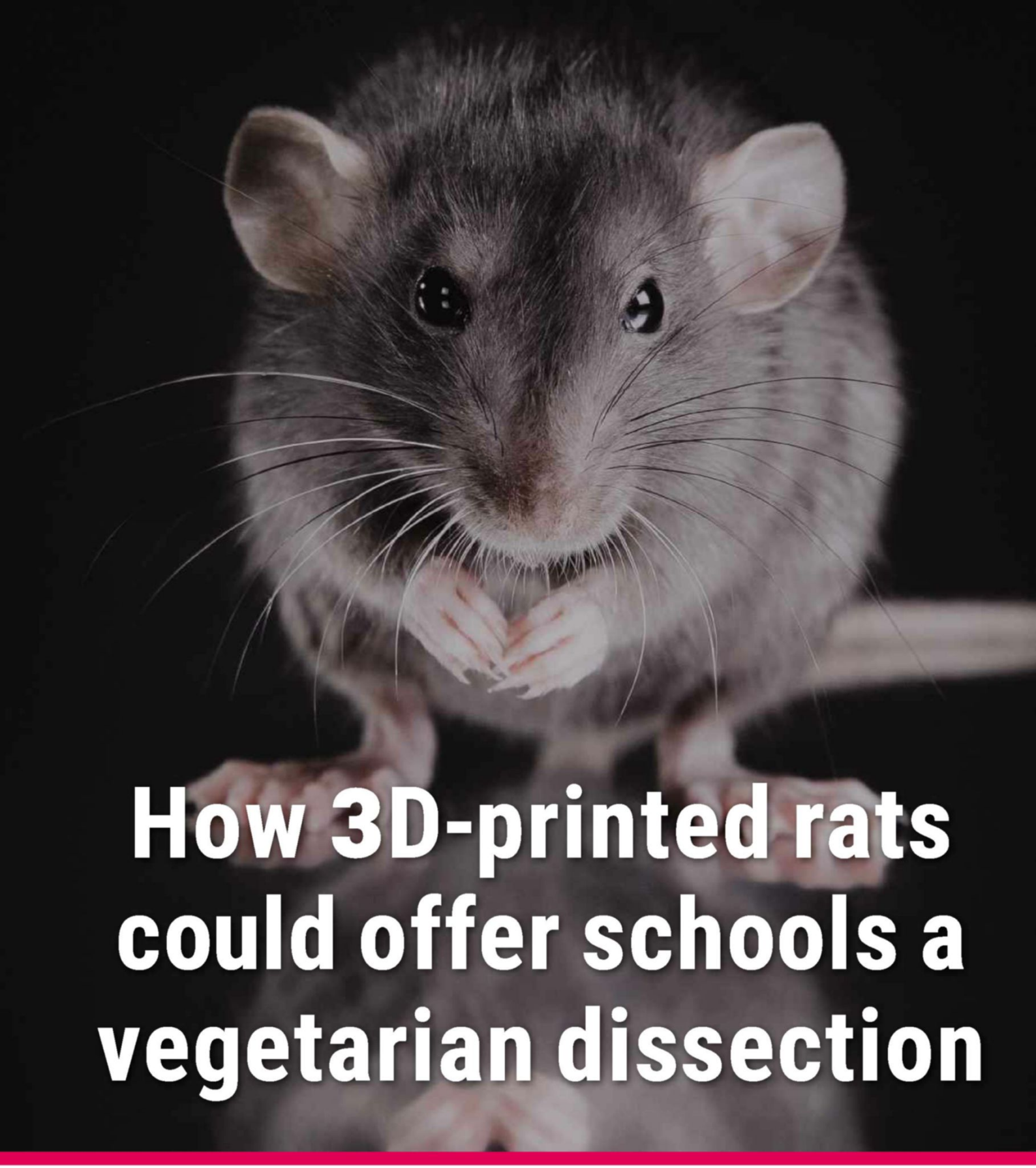
Vermintide is also much bigger than Left 4 Dead, including 13 campaign missions and multiple smaller side-quests. However, it lacks the quality of Turtle Rocks' masterpiece. The environments, while well designed, are spoiled by dark, murky textures that make every mission feel depressingly similar. The missions themselves are simply too long with no opportunity to save progress during them. There's no bot support either, and the game requires four players in order to work, which can result in lengthy wait times for a game.

Then, when you're in the game, the characters are too large and too slow, while combat is lightweight and spongy, as if all the weapons are made out of bread. There are exceptions, such as the Witch Hunter's Zweihander and flintlock pistols, which feel sufficiently lethal, but they're exceptions. In the end, Vermintide feels like a supermarket value product. It will satisfy your coop shooter needs for a while, but you can't help yearning for the real thing.

RICK LANE

OVERALL SCORE
60%

/ VERDICT
Vermintide's aping of Left 4 Dead's structure makes it a passable distraction, but it also highlights its own inadequacies compared to Turtle Rock's original and best.



How 3D-printed rats could offer schools a vegetarian dissection

alphr.com
A fresh take on technology

Just Cause 3's vehicle handling has allegedly been improved through Havok physics, although this only works when the car is on the road in the first place

RICK LANE / THE ENGINE ROOM

Avalanche

Rick Lane parachutes into the tech behind the spectacular Just Cause open-world sandbox games

When it was released back in 2010, Just Cause 2's virtual island archipelago of Panau was one of the largest true-3D open worlds ever created. Its landscapes ranged from rugged mountain ranges to thick tropical jungles and even a sprawling metropolis.

It was a tremendous achievement in terms of environment design, and the game was fun to boot, so you might be surprised to learn that the developer wasn't entirely satisfied with its work on Just Cause 2. 'We felt limited by the way the landscapes were represented,' says Linus Blomberg, co-founder and CTO of Avalanche Studios, developer of the Just Cause series. 'In Just Cause 2, we used traditional height maps for terrain, like most other open-world games, but their two-dimensional nature negatively affects what kinds of landscapes you can express.'

In the five years since, Avalanche has been quietly working on multiple projects, culminating in two games launching this year within months of each other. One of them, the upcoming Just Cause 3, runs on an entirely new version of the developer's eponymous engine, which includes a radically rethought method of sculpting 3D landscapes.

'This new technology is what we internally refer to as "digital clay",' says Blomberg. 'It's an entirely new and groundbreaking landscape technology based on a volumetric data representation known as "scalar fields". This technique is common in medical visualisation, for rendering volumetric data sets captured from CAT-scans.'

To give a basic summary of how volume rendering and scalar fields work, a scalar field assigns a single value to every point in a given space, which can either be a mathematical 'real' number or a physical quantity. It works differently from vectors, which use multiple numbers to calculate points in space – usually x and y values when referring to 3D graphics. Physical scalar fields have units of measurement associated with them, but they must be independent of the coordinate system used to describe them. As such, two observers using the same units of measurement will agree on the value of a scalar field at the same absolute point of space.

Scalar fields can be used to render 3D datasets as a highly accurate 2D projection. Where generating a

traditional height map will provide a rugged mountain terrain, volume rendering using scalar fields can also account for terrain layers that would otherwise be obscured by those mountains. Examples include tunnels or cave networks running within those mountains, terrain that overhangs other terrain and so on.

'The new landscape technology allows for more detailed and complex topography. The enormous size of the world is still there, but this makes the environments much more dense and interesting, and also in the smaller scale,' says Blomberg. This more intricate landscape should also be noticeable from the air, which is important in a Just Cause game where the player spends a lot of time airborne.

Alongside large environments, the Avalanche engine is also known for its destructive capabilities, which have been expanded for Just Cause 3 in various ways. 'Central to the gameplay of Just Cause 3 is what we like to call "chains of creative destruction,"' says Blomberg. 'Since everything is physics-based, you're able to set up (and set off!) these domino effects, where one explosion causes another one to go off, which pushes another physicalised object off a ledge, creating another explosion, and ... you get the idea.'

Complementing these chains are much larger destructible objects, including long concrete bridges that span plunging valleys, and speeding cargo trains that can be derailed. 'Also, Just Cause 3 is exclusively for new-generation hardware, which enables us to crank up explosions and particle effects several steps above what was possible with Just Cause 2,' Blomberg adds.

Elsewhere, Avalanche has adopted a physically-based approach to rendering, previously seen in games such as Metal Gear Solid V. This term essentially means lighting objects in a way that mimics the physics of light as accurately as possible, calculating how light reflects and scatters off objects, and how that secondary light illuminates other objects, resulting in much more realistic-looking materials.

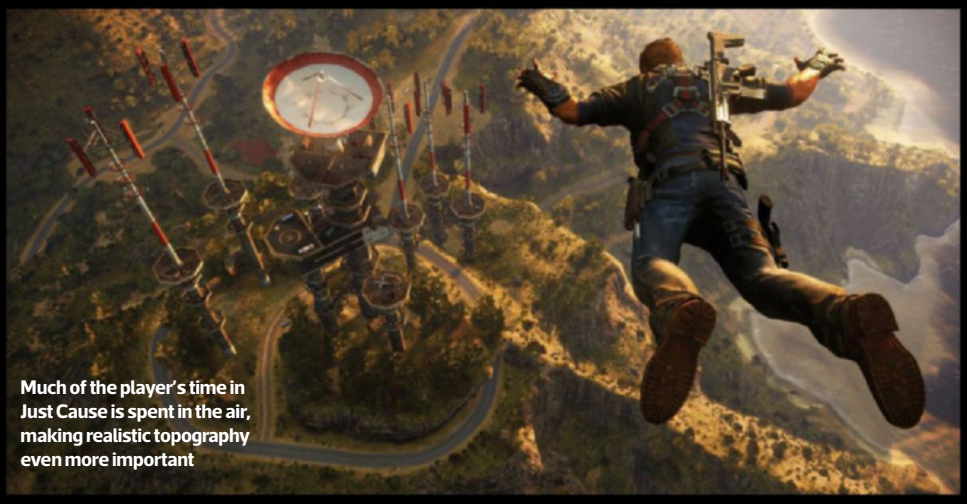
In addition, the developer has taken a hard look at one of Just Cause 2's biggest bugbears – vehicle physics. Most of Just Cause 2's vehicles handled like a milk float on marbles, so Avalanche has built Just Cause 3's vehicle simulation on the Havok physics engine. 'Everything in the simulation is defined at very high detail, down to the gear ratios and traction of the wheels, and is carefully balanced for each individual vehicle. Some of the vehicle designers on our game come from an arcade racing background, which should give you some idea of what we're shooting for,' says Blomberg.

Just Cause 3 isn't the only Avalanche-based game to release this year either. September also saw the launch of Mad Max, Avalanche's tie-in game published by Warner Bros. Curiously, Mad Max employs the previous iteration of the Avalanche engine, and doesn't employ the studio's digital clay tech. The older engine 'made more sense for that game as it's based mainly on the ground,' explains Blomberg, 'and it meant we could use a well-proven tools pipeline, which enabled us to focus on the challenges of crafting a highly detailed and atmospheric wasteland.'

Consequently, the design of Mad Max was more about designer skill than technological prowess – creating different regions that felt unique but stuck to the 'wasteland' theme of dry, barren and deserted landscapes, while breaking up the horizon with regular landmarks such as beached ships and abandoned power stations, imbuing a sense of dynamism to a dying world through violent dust and lightning storms. 'We've always worked a lot with weather effects in our games, and have great support in our engine for it. But in the end, to get to that level, it really comes down to a lot of hard work and great craftsmanship,' says Blomberg.

That environmental craftsmanship is evident in Mad Max , and it will likely be up to a similar standard in Just Cause 3 too, aided by Avalanche's upgraded engine. The question now is whether the sandbox experience will have progressed sufficiently to compete in a year where the open-world genre has made major strides forwards – most notably in The Witcher 3's astonishingly characterful world, and Metal Gear Solid V's beautifully layered stealth systems.

Blomberg is confident. 'With Just Cause 3, we took the generational leap over to the new technology, with all of the risks that means,' he says. 'We felt the reward from that technology in the kind of vertical gameplay Just Cause 3 provides was too great not to pursue.' **GPD**



Much of the player's time in Just Cause is spent in the air, making realistic topography even more important

Medici's rugged coastlines highlight the landscaping improvements from Avalanche's digital clay tech

Subtle colour shading and regular landmarks prevent Mad Max's landscape from feeling monotonous

CUSTOM PC MAKES A VIDEO GAME

PART FIVE

What's on Rick Lane's menu this month? Menus, of course! How meta ...

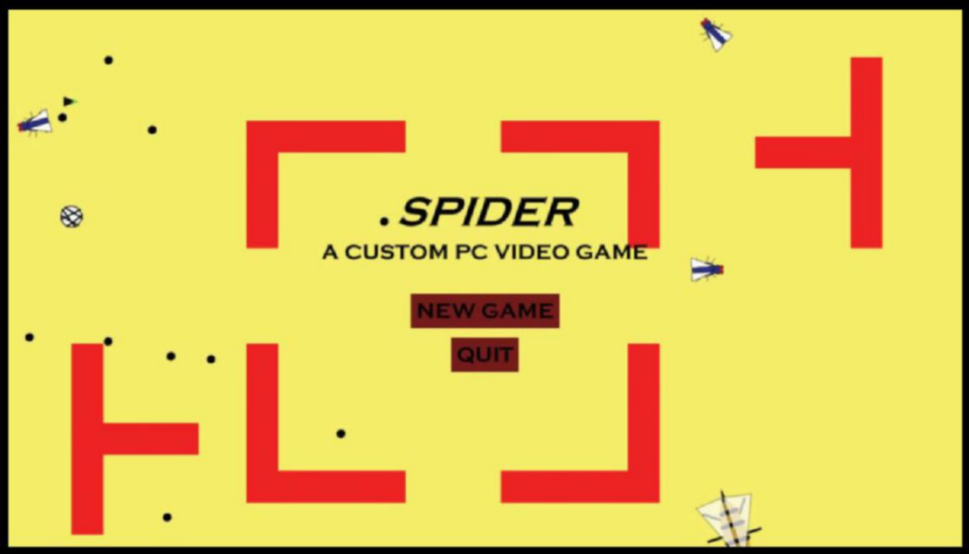
This month, in our continuing effort to create a video game with all the programming knowledge of a medieval peasant, we did a little more tweaking of collisions before adding a proper start menu to our game. We then made several more fundamental changes to how the combat functions, primarily the addition of an overarching ammo system for several of our weapons.

We left off last month having successfully implemented both player and AI collisions, which also enabled the construction of some basic level layouts.

However, there was one problem; although the player could no longer 'move' through solid objects, shooting both the Web Trap and the Shotgun caused kickback, which could push the player through solid objects. Fortunately, the fix just involved a simple script that resets the kickback's directional values to zero whenever a solid object is encountered.

With this last collision-based bug squashed, we could finally step away from the fiddly job of collisions and move to the next stage of Tom Francis' GameMaker tutorial – creating a menu. To be honest, our game is so basic that adding a menu seems a little like overkill. Yet given that most games have one, it's a topic that's worth exploring structurally.

As it turns out, creating menus in GameMaker is weird. A menu is built using the same 'room' object category that forms the basis of game levels, so we created an invisible 'Menu' object that's dropped into the Menu room, and added a 'DrawGUI' event to that object. As you can no doubt guess, these events are designed specifically around the building of a user interface.



Pressing Escape in-game brings up the menu as an overlay

The button's opacity fades slightly when you hover the mouse over it, highlighting that it can be clicked

At its most basic, our Menu UI needs three items: the title of our game, a button that starts the game and a button that quits the game. In GameMaker, all of these features could be created – or at least laid out aesthetically – in a straightforward manner using the toolset's visual scripting system. However, as we're following Francis' tutorial, we're coding these parts directly, which is more complicated.

We began with the title. It's possible to program text to appear in a GameMaker room simply by writing 'draw_text(x,y,TEXT GOES HERE).' But that command just draws some text in the room at the given X,Y location. More specific control of text can be achieved through GameMaker's 'Fonts' folder, where the font style and size can be

determined, then set as an object that can be called into the game via the 'draw_set_font' command. Even then, though, values such as the space between individual lines of text must be defined manually.

Creating buttons is even more complicated because they need to be interactive. Francis approaches the creation of a button first by 'drawing' a rectangle around the button, followed by assigning it a colour, adjusting the opacity of the rectangle when you hover over it with the mouse, and then assigning it a command for when the mouse is clicked within the area of the rectangle.

Curiously, creating the interaction of the button is the least complicated process. Functionally, the 'Start Game' button simply switches over from the menu room to the game room, using the 'room_goto' command. We already have a command for quitting the game ('game_end') assigned to the Escape key, and it can be easily transferred to the 'Quit' button once it's in place, while we reprogram the Escape key to bring up the menu overlay.

The most difficult part of this process is creating the rectangle overlay for the button in the first place. Even with Francis' tutorial to hand, getting the proportions right through code requires multiple iterations. Eventually, though, we produce a working if extremely basic menu. To give it a little something to draw the eye, we cobble an AI-controlled version of our spider character, which crawls around the screen while the player struggles with the impossible choice of whether to start the game or quit.

With the menu screen in place, we began refining the game mechanics. Early on in this series, we decided to make the spider grow every time it ate a fly, but since the introduction of wasps, and especially since the addition of solid objects, it's clear this aspect isn't going to work. The rapid growth of the spider makes him a massive target, and causes him to become stuck between objects easily.

Moreover, we also want to limit the number of shots the spider can take with his weapons. We introduced a basic ammo system for the Sting Shotgun in the last part, but the Web Trap and Web Grenade both have unlimited ammo. Because these weapons are thematically similar, we decided to introduce an overarching ammo system for them, simply known in-game as 'Web'. The premise is that the Web Trap will use a small amount of Web, but sprays it in a continuous burst, while the Web Grenade will use a single, large chunk of Web each time it's fired.

There are a few ways to get this feature working, but we decided to experiment with global variables. Variables are words to which the developer assigns a function or value, and in GameMaker they're associated with a specific object. By comparison, global variables can be called by any object in GameMaker. They're created with the phrase 'globalvar' followed by the word in question, which in this case is 'Web'.

We assigned a starting value to Web – 'Web = 100' and then created a second Global Variable 'WebMax,' set to '1000'. The remaining process is broadly the same as that used for the Sting Shotgun; instructing each weapon to subtract a given amount from the 'Web' variable each time that weapon is fired, and to only fire if that amount is greater than zero. Lastly, we attached a line of code to the Fly that adds 50 'Web' to the variable total each time a fly is eaten from a trap.

We then adapted a feature from Francis' tutorial – a power-up bar that indicates the player's power – to represent our total Web count. This feature involves relatively complex code that draws a rectangle across the bottom of the screen, which fills in and erases out in accordance with how much 'Web' ammo the player has available.

The result of this month's efforts is a game that feels better balanced in terms of the player's and enemies' abilities. The weapons feel powerful but the ammo depletes rapidly, and the player must balance trapping and eating flies to replenish their Web, with keeping the screen clear of enemies. With the Menu in place, the structure of the game is also becoming clearer. Next time we'll be looking at aesthetic improvements, including some animation. OPC

Event: oWebShot_Step_1

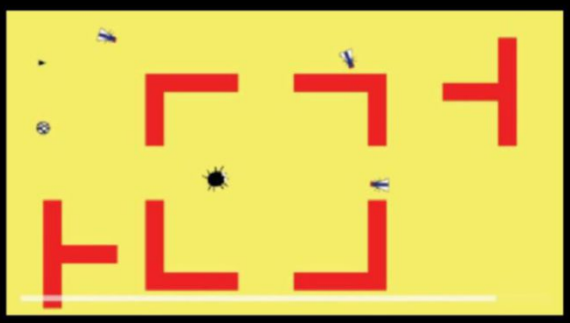
Applies To: Self Other Object:

action

```
13
14 if mouse_check_button (mb_left) and global.Web > 0 {
15
16    MyProjectile = instance_create (x,y,oWeb)
17
18    MyProjectile.direction = image_angle - 180
19
20    MyProjectile.speed = 600 / room_speed
21
22    MyProjectile.image_angle = image_angle
23
24    audio_play_sound(aWebSpray,2,false)
25
26    Kick = 300 / room_speed
27
28    KickDirection = image_angle
29
30    Owner.xShunt = lengthdir_x(Kick,KickDirection)
31    Owner.yShunt = lengthdir_y(Kick,KickDirection)
32
33     global.Web -= 1
34
```

The completed code for our Web Projectile, including added global variables

Getting buttons to work is fairly straightforward, unlike making rectangles that line up properly



It's hard to see, but there's now a bar at the bottom that shows how much 'Web' the spider has available

VALVE'S STEAM MACHINES DEPLOY A LINUX-BASED OS AND A BRAND-NEW CONTROLLER IN AN ATTEMPT TO CONQUER THE LIVING ROOM. **MIKE JENNINGS** TRIES OUT TWO STEAM MACHINES AT HOME TO SEE HOW THEY FARE

STEAM MACHINES

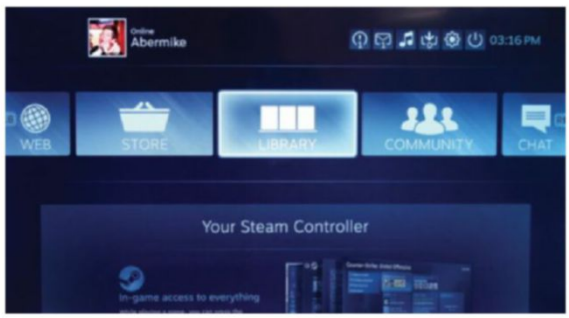
The battleground between PC and console is well established. PC enthusiasts cite cheaper games, better graphics and more versatility, while console fans reply with ease of use, living room comfort and cheaper devices. Valve promises to bridge that gap with Steam Machines, which promise the usability of consoles alongside the cheaper, better-looking games that PC users enjoy.

The new devices are attempting to bring PC gaming to the living room, but that strategy opens up Valve to competition from all angles. The PS4 and Xbox One are the current kings of the couch, and on the PC, Windows has a much wider games catalogue.

STEAMOS EXPLORED

Anyone familiar with Steam on Windows will soon be at home with SteamOS. It's Linux-based, but it follows the blueprint laid down by Steam's Big Picture mode – the option that reconfigures Steam for living room use. The UI uses the '10-foot user interface' idea that governs console and Smart TV design – it's designed to be easily navigable from the sofa, which means large text and icons, and a layout designed for control pads.

The main screen serves up big buttons for Steam's primary sections:



The UI is designed to be easily navigable from the sofa, which means large text and icons, and a layout designed for control pads

the store, your library and community are central, and pressing the shoulder buttons opens up web and chat interfaces. Below these bits is a welcome message, and above them are smaller icons for notifications, downloads, settings and power.

The library and store are both straightforward, and can be customised with filters.

Like many other areas of SteamOS, the store will be familiar to Big Picture users. There are categories for top-selling titles and new releases, and a section called 'For You' that provides genre-based recommendations. The community and chat sections are lifted straight from Big Picture mode too – it's easy to find friends in a big grid of profile pictures.

SteamOS' PC origins are also obvious in the options section, where you'll find the ability to tweak audio

output, screen position and networking, and it's possible to see precise information about the system and its software. Updates are easy to find and install too.

LIFE WITH STEAMOS

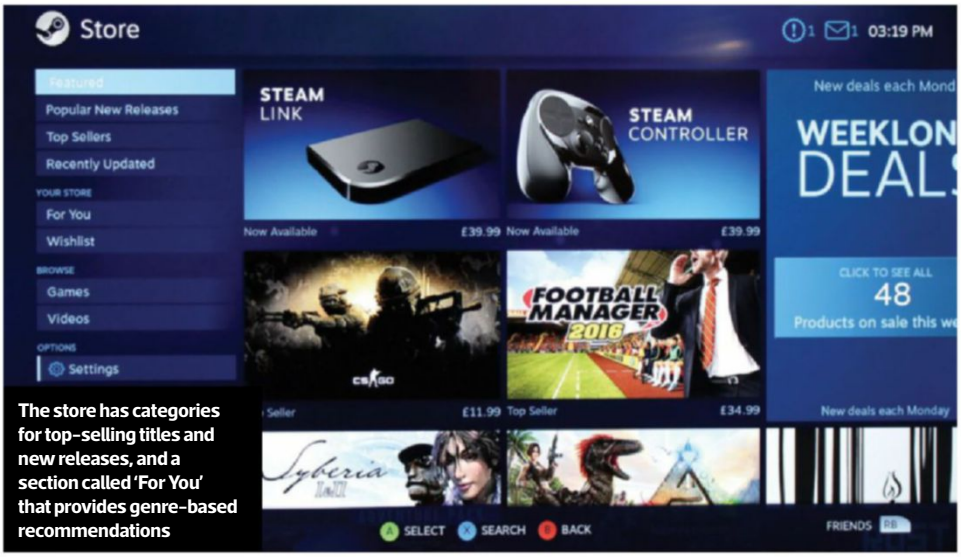
The SteamOS setup procedure is as simple as with any console. The machine boots and asks for a Steam Controller to be paired, and then you just have to add networking details and log in. The machine will spend a minute configuring, and that's it.

Navigation is stellar: menus scroll smoothly and new pages open swiftly, with no hint of juddering. If you tap the left and right shoulder buttons in the OS, the browser page and chat page respectively whizz open with impressive speed, and we were always able to tap the controller's Steam button to open up in-game options or the main menu.

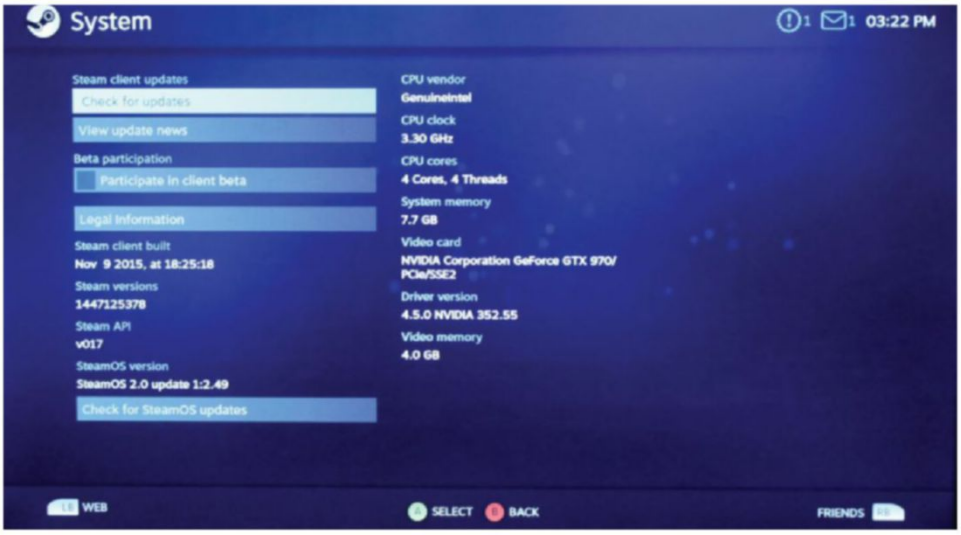
It's easy enough to download games too, and getting them working with the controller is generally simple: some titles such as Civilization V have control schemes provided by the developers, and others such as Valve's own Portal 2 are supported from the outset.

Others rely on Valve's templates or community-made schemes. Three templates are available – a generic gamepad scheme, a high-precision gamepad setting and another setting that mimics keyboard and mouse controls. In the case of Borderlands 2, the middle option is selected, and it works fine, although the text and images in the game's control options menu still refer to the Xbox 360 pad.

There are other pleasant touches as well. The OS scans the system for audio files to use as a backing track, for example. There are also two on-screen keyboards – one that uses both of the controller's touchpads, and another that uses a daisy-wheel system – and both are intuitive given a little familiarisation.



The store has categories for top-selling titles and new releases, and a section called 'For You' that provides genre-based recommendations



It's possible to see precise information about the system and its software in the settings

Some games, such as Valve's Portal 2, support the Steam Controller from the outset

Streaming is possible too, from Windows machines to the Steam system. It's one way of solving the problem of a game not working on SteamOS, although it does require two systems to be running and it only functions on wired networks.

By and large, there's a lot to like. SteamOS is quick and intuitive, it has more options than most consoles, and games can be downloaded and run without hassle.

RUNNING OUT OF STEAM?

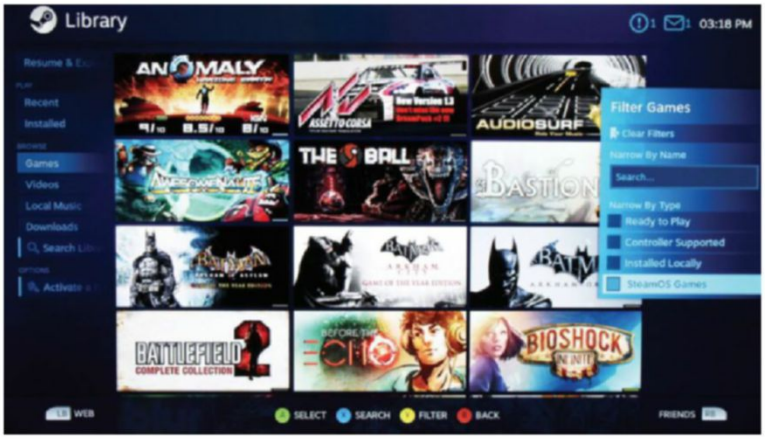
There's one major elephant in the room with SteamOS, and that's the Linux build underneath the sofa-friendly UI. The reliance on Linux means there's a dearth of games: third-party data tool SteamDB has confirmed that 1,428 games work on SteamOS at the time of writing.

That sounds like a large number, but it pales in contrast to Steam on Windows, where nearly 15,000 games are available. Valve has added almost 1,600 new Windows games in 2015 alone, so it's going to take a colossal effort for SteamOS to even keep up, let alone catch up.

The SteamOS library is larger than those of the consoles, at least: the PS4 and Xbox One currently have 822 and 495 games respectively. Those figures include more triple-A titles than Valve's system can manage, though, and the PS4 in particular is also loaded with indie games. Sony's system shows no sign of slowing its momentum either.

That situation will improve as more games emerge for SteamOS, but right now, the store looks bare. By default, the storefront doesn't display games that won't work on SteamOS, which makes sense, but that logic doesn't follow to other areas. The For You section promotes games such as Fallout 4, Assassin's Creed: Syndicate and Call of Duty: Black Ops 3, for example, even though they don't work on SteamOS.

The Library suffers similarly: it displays every game you own, and the option to only display SteamOS titles is hidden away in the filters.



The Library displays every game you own, and the option to only display SteamOS titles is hidden away in the filters

By default, the Library is a screen full of games that you can't play, which is a kick in the teeth and a reminder of the competition.

Sadly, these small niggles rob SteamOS of the cohesion we expect. The control methods aren't consistent either: we were able to use the controller's dual touchpads to log in, but were thrown back to a traditional on-screen keyboard to input Wi-Fi passwords. The D-pad inscribed on the left-hand pad can't be used for navigation either, which is another odd decision.

SteamOS can't match rivals when it comes to media either. The basic web browser isn't much cop either, with few options aside from a tabbed browsing ability. You use a cursor on the webpage itself, but you have to use the Steam Controller to use options in the browser, so you're always switching between two different kinds of navigation.

There's also no sign of the media apps such as Netflix, which are common on consoles and the latest versions of Windows. Living room PCs and consoles are now media machines as much as gaming systems, and SteamOS falls down here badly.

Our experience wasn't entirely smooth when working with Valve's games and third-party titles either. Portal 2 and Borderlands 2 both defaulted to a resolution of 1,024 x 768 despite using a high-end system and a 1080p TV, and Trine 2 wouldn't open some menus unless we used a mouse. These issues are easy enough to circumvent, but they rarely crop up on consoles.

Likewise, Left 4 Dead 2 is one of Valve's games but, sadly, getting it running wasn't a smooth process. It booted at 1,600 x 900 despite our 1080p TV, and its official controller configuration was poor: mouse movement was so twitchy we couldn't play the game, and there's no way to switch to a secondary weapon using Valve's controls. The former issue could only be fixed by leaving the game and heading to SteamOS' settings, as the in-game mouse sensitivity slider made no difference.

Many faults are easy to fix, but we shouldn't have to fix them – on a console, and even on many Windows machines, they just wouldn't occur.

It isn't a big ask for experienced PC gamers, but it could be enough to put off lapsed desktop players or console gamers intrigued about a switch to Steam.

THE STEAM MACHINE LANDSCAPE

The Dell-made Alienware Alpha measures just 56mm tall and 200mm wide

In this feature we've concentrated on systems from Scan and Syber. The PCs we've covered are high-end configurations, but they aren't the only options available. Scan, for instance, has four models that range in price from £494 to £905 inc VAT, with our sample costing £899.

They're all in different cases and, given those price differences, the components change too: at the low end, you're looking at a Core i3 processor, GTX 750 Ti graphics and a 1TB hard disk, while pricier machines have Core i5 chips, GTX 960 and GTX 970 GPUs and SSDs. These Scan 3XS machines are completely customisable too.

Syber's machines are similarly versatile. The firm offers four devices with prices from £499 to £1,205 inc VAT. Interestingly, Syber's £695 and £1,205 machines both rely on Haswell processors, with Core i5 and Core i7 parts deployed, but that's fine for 1080p gaming. They also both have only 1TB hard disks rather than SSDs, although they certainly stack up in the graphics department: the former has a GTX 960 and the latter a GTX 980. Our £999 sample sits in the middle of the range. Like Scan, every machine can be customised, with a vast range of processors, motherboards, GPUs and storage options. In that respect, the Syber and Scan systems are exactly like gaming PCs.

The third big player in the UK's Steam Machine landscape is the Alienware Alpha. This Dell-made unit measures just 56mm tall and 200mm wide. It also has a low price. The four configurations range in price from £449 to £699 inc VAT. The svelte design and lower prices result in performance trade-offs though. The processors used are older, low-power models, and they only have 4GB or 16GB of memory alongside sluggish hard disks. Meanwhile, the GPUs are bespoke Nvidia parts with just 2GB of memory, and the low-end machines using parts based on the GTX 750 Ti.

Numerous other Steam Machines have been announced too, but they're not yet available in the UK. Systems from Zotac, Asus and Gigabyte are all on the way.

POWERING UP THE STEAM MACHINES

We've locked and loaded two Steam Machines for Valve's big launch. The Syber Steam Machine K comes from CyberPower (**www.sybergaming.com**), and the 3XS ST10 is built by Scan (**www.scan.co.uk/3xs/custom/steammachines**).

Scan's machine arrives in a new Fractal Design case. It looks at home beneath a TV: its brushed aluminium exterior, single white LED and short, wide design make it look like a console or a Blu-ray player rather than a gaming PC.

The Scan's top cover pulls away to reveal sensible innards. The Asus mini-ITX motherboard sits on one side with the small PSU, and the other half is dominated by the EVGA graphics card that uses a riser to lie horizontally. Meanwhile, the SSD sits in a small cage with another drive bay free.

Syber's system is more conventional. It's wider and taller than the Scan, and its looks are louder; the front is illuminated by two bands of light amid plastic ridges, and its sides are covered with glossy material.

It still isn't as sturdy as the Scan – it's made from plastic, which flexes to the touch.

The Syber follows the same blueprint as the Scan though: the mini-ITX motherboard and power supply take up one half, with the graphics card occupying a stretch of chassis opposite. The card is a little trickier to access, though, because it's in a metal cage beneath the hard disk.

Both machines are littered with USB 3 ports and DVI, HDMI and DisplayPort outputs. Syber's machine has the added bonus of dual-band 802.11ac Wi-Fi, though, while Scan's machine has no Wi-Fi capabilities.

The Syber's front is illuminated by two bands of light amid plastic ridges

In terms of graphics, both machines rely on overclocked versions of Nvidia's GeForce GTX 970 GPU. The Scan's EVGA card boosts the core from 1050MHz to 1190MHz, while Syber's MSI model runs at 1102MHz. The machines diverge elsewhere. The Scan has a Core i5-6600 processor, 8GB of memory and a 1TB hard disk, while the Syber has double the memory and storage space and a Core i7-6700 CPU.

Those differences are reflected in the prices: the Scan costs £899, while the Syber costs £100 more. We'd argue that the Syber is just too much:

One half of the Scan is dominated by the EVGA graphics card, which uses a riser to lie horizontally

the GTX 970 will easily handle 1080p games with aplomb, and these machines just don't need a Core i7 processor or 16GB of memory. Plus, if you wanted to make the jump to 4K SteamOS gaming, you'd need a faster GPU anyway.

Neither machine gave us heat issues, and Scan's machine won in the noise department: it's near-silent, while the Syber made a similar noise to the current consoles. In this respect, the Scan was mainly helped out by its Arctic Cooling Freezer 11LP cooler, while the Syber machine relies on Intel's stock unit.

These systems both have the power required for living room gaming at 1080p, but Scan's machine offers a better balance: it still has enough power, but it also has a better chassis, lower noise levels and a £100 cheaper price tag.

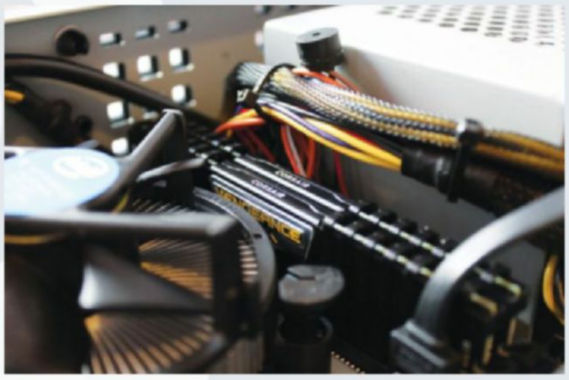
TAKING CONTROL

The Steam Controller represents the first time Valve has produced its own control pad, and its importance cannot be understated – it's a crucial link between the living room and the gaming PC. From afar, its black plastic and curved corners make it look like Sony's DualShock 4, but plenty distinguishes Valve's hardware from its rivals. The face is dominated by two large, circular pads designed to mimic mouse actions: the left-hand pad defaults to scroll-wheel functions, while the right-hand unit behaves like a mouse's movement.

Four colour-coded buttons sit alongside a single analogue stick, and the central Steam button sits between two more buttons. There are six buttons around the rear: two traditional shoulder buttons on each side, and two more on the base.

The Steam Controller doesn't just have more buttons than console controllers, either. It also has haptic feedback that goes beyond what other controllers offer – the pads whirr with feedback designed to mimic mouse movement, and the analogue stick clicks. The Controller also has a gyroscope, to enable keen gamers to improve their aim.

There are loads of customisation options too. The right-hand pad can be tweaked with dozens of settings: sensitivity tweaks, acceleration and friction alterations and haptic intensity are all adjusted with sliders, and the pad's base functions can be changed – select a joystick rather than a mouse, for instance, and you're set for flight sims. There are also advanced settings to tweak double-tap speeds, movement thresholds and sensitivity settings for different axes.



Top: Scan's use of an Arctic Cooling Freezer 11LP cooler helps to keep down the noise

Above: The Syber machine's 16GB of RAM is overkill for a 1080p gaming rig

Other buttons are similarly tweakable. The left-hand pad can be bound to particular actions and doesn't have to be used as a scroll-wheel, and the analogue stick can have its haptic sensitivity and bindings changed.

You can also temporarily alter button actions by picking a button to assign as a Function key, enabling you to add secondary functions to the buttons. Meanwhile, the trigger buttons get their own options, with customisable actions for full and soft pulls and the ability to tweak the levels at which those inputs are distinguished.

You can tweak the right-hand pad's sensitivity, acceleration friction and haptic intensity with sliders

Many buttons can also be tweaked with a Turbo option so you can repeat-fire without constantly hammering the buttons – handy for fans of third-party controllers from the 1990s – and the repeat intervals for every button can be changed in the advanced menus. There are dozens of options, but they're never overwhelming – they're all organised sensibly, with clear explanations.

However, despite all the options, we aren't totally sold on the Steam Controller due to a handful of hardware irritations. The two circular pads are a little too difficult to click, and the top shoulder buttons suffer similarly – they should be designed for rapid tapping, but they need too much force to actuate.

The right-hand pad also suffers due to its size: during first-person titles and strategy games, you often run out of room and have to take a split second to move your finger back to the middle. That's fine during slower-paced games, but it could prove ruinous in the heat of battle. The sensitivity of the right-hand pad is a hot topic too. By default it's extremely twitchy, which will suit players used to high-resolution gaming mice, but console gamers or those who prefer a slower speed will want to tone it down immediately.

The analogue stick is small compared with console sticks, the four coloured buttons are small and close together, and the two buttons on the underside are too easy to press.

These criticisms are minor niggles, but they combine to undermine Valve's good work. The Steam Controller has more buttons and options than any rival, but it doesn't feel quite as solid and satisfying in use as pads from Sony and Microsoft.

THE FUTURE

SteamOS and the Steam Controller have their issues, but we could never accuse Valve of standing still – its hardware and software have constantly improved since their debuts, and we've no doubt that the OS and its hardware will continue to be refined.

However, the main issue isn't ironing out the niggles that emerged during our testing – it's getting more games onto the machine. SteamOS is miles behind Steam on Windows in this respect, and games aren't being added

at the same rate, so you're missing out on big releases, interesting indie titles and older games.

The dearth of games is a problem when you compare a Steam Machine to a console, too. In theory, it has more games than both the PS4 and Xbox One, but those devices do better when it comes to Triple-A releases – a key factor when Steam Machines are aiming to convince gamers to switch platforms.

There's more work to do, and for some firms it can't come soon enough. For example, Falcon Northwest is one of the US' biggest PC builders, but it's declined to release a Steam Machine because of the limitations around high-end specifications – an issue that the firm hinted was caused by poorer performance on Linux because of unrefined graphics drivers.

Recent tests by Ars Technica also found that games were significantly slower under SteamOS than Windows. A dual-booting system lost around 10fps in Middle Earth: Shadow of Mordor at Very High settings, and the same gap was recorded in Metro: Last Light. Performance even suffered in Valve's own Source engine.

AMD and Nvidia have often struggled to provide Linux drivers that can match Windows machines for performance, and it looks like SteamOS suffers as a result. It's another area that needs some development if Steam Machines are to succeed.

Origin PC, meanwhile, is another US system builder that got cold feet after initially throwing its weight behind Steam Machines. The firm has decided it's better to build Windows machines that boot into Steam's Big Picture mode in and use the Steam Controller, chiefly because of the larger Windows games library.

THE NEXT BIG THING, OR JUST HOT AIR?

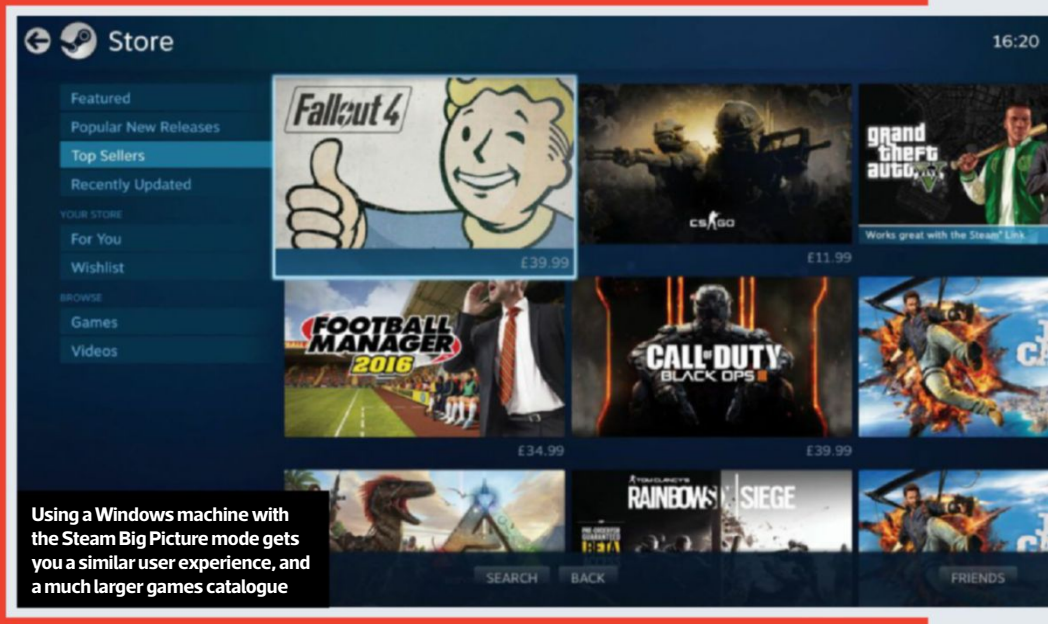
Valve's SteamOS, Steam Machines and controllers have been in the pipeline for years, so we're pleased that they've finally emerged – and hands-on time with two systems reveals that there's plenty to like. The UI has taken years refine, and it works well: it's smooth, fast and intuitive, with plenty of options and reasonable support for the Steam Controller, whether that's from official sources or Valve's pre-made templates.

SteamOS is designed to mix the versatility of a PC with the coherence of a console, though, and the current setup doesn't quite cut it: the Linux underpinnings mean the number of games is far short of any Windows machine, and various interface niggles and a dearth of apps mean the software can't match the slick all-round experience of current consoles.

The controller, too, is a mixed bag. It has more buttons and options than any other mainstream gamepad, but the end experience can't quite match that of current Sony and Microsoft controllers. Of course, the situation will get better: drivers will improve efficiency, more games will appear, features will be added and future versions of the controller will be even better. But at this point, SteamOS is still playing catchup with the big consoles, and it needs to do far more if it's going to compete with them.

There's lots of potential here, but Steam Machines remain a tricky proposition for the present. Right now, consoles are cheaper, slicker and have more media options and triple-A games. Meanwhile, Windows PCs can use Steam's Big Picture mode and the Steam Controller to provide the same experience with a vast games library.

The first Steam Machines are decent for living room gaming, but they'll struggle to overhaul such strong competition, and changing that situation will require a lot of work – we're concerned that Steam Machines might be too little too late. CPC



Using a Windows machine with the Steam Big Picture mode gets you a similar user experience, and a much larger games catalogue

WINDOWS-BASED ALTERNATIVES

The rise of efficient components and mini-ITX motherboards means it's easier than ever to install a tiny gaming PC in your living room, so Valve has competition from Windows-based machines as well as consoles.

For starters, Syber sells a range of systems it's dubbed Vapor, which come in the same chassis as its Steam Machine, and there are even more specifications available: prices range from £485 to £1,905 inc VAT, across seven models, some of which will be able to handle gaming on a 4K TV. Scan will sell its Steam Machines as Windows models too, although you'll have to ask the company directly and add the price of an OS. Alienware, too, sells its Alpha as a Windows machine, with similar configurations and prices.

Look outside of these Steam-style systems, though, and you'll find a whole world of small form factor machines. The range of Atomic machines from Overclockers can be configured with a GTX 970 graphics card and Core i5 processor for around £800, and PC Specialist can sell you a Core i5 machine with an AMD Radeon R9 380X graphics, a Samsung SSD and a 1TB hard disk for just over £900.

They're tempting, but they're for living room gaming, so a controller is also required. The Steam Controller costs £40 on its own, an Xbox One pad costs around £35 and an Xbox 360 controller is cheaper if you scour eBay. Run Steam's Big Picture mode on a Windows machine with a gamepad, and you'll get access to a much bigger game catalogue for the small price of a Windows installation.

Media studies

Antony Leather investigates the various options available for home media streaming, and looks at the ideal kit for building an HTPC

The home theatre PC (HTPC) was dealt a bit of a blow with the launch of Windows 10 – it no longer included Windows Media Center (WMC). In some ways, it's a relief – Microsoft had never given Media Center the support it needed to thrive and the application was mainly reliant on third parties for features. Even at the end of its life, it wasn't able to offer a complete experience, but it came pretty close.

So what now for the HTPC? Well, many people have already ditched WMC in favour of more streamlined, modern programs such as XMBC – now called Kodi, and Plex too. The HTPC can also claim to support every streaming service and content formats – that's the benefit of using Windows. However, the HTPC has some stiff competition now.

NAS enclosures are offering increasingly large lists of features aimed at streaming and capturing content. Meanwhile, media streamers offer similar functions as well as allowing the use of streaming services such as Netflix, while some have the ability to browse the Internet.

Then you have smart TVs, which are essentially TVs with built-in media players that can access popular streaming services and play content from USB sticks. Finally, there's e a growing number of HDMI-based media streaming

devices such as Chromecast. These devices can pair with smartphones and other devices, such as NAS enclosures, to stream your content directly to your TV from local files or Internet streaming services, often from cut-down but fully fledged versions of Chrome OS, Windows 10 or Android. The question, then, is do these products actually make the HTPC redundant, or is there still a place for it in your lounge?

In this feature, we'll be trying to answer that question, looking at some of the gear that's looking at replacing the HTPC, as well as the latest hardware you can use to make an HTPC yourself.

Synology's smartphone DS Video App transcodes video on the fly

Why the HTPC is a great media device

One of the biggest reasons to get an HTPC over other devices is its universal content support. A Windows-based machine can tap into practically all streaming services, such as Netflix, BlinkBox, iPlayer, NowTV and many more, and limited support for various services has often plagued Smart TVs and media streamers. Even if the latter could support the vast majority of these services, there are other benefits of an HTPC, such as local content playback of almost any file format.

Many smart TVs are also unable to play high-quality audio files such as FLAC or ALAC, which is also an issue for some HDMI media players. Even if they do support streaming of FLAC files, for example, the source device usually transcodes them to lower-quality formats to be compatible, as do many media servers such as Plex.

Video files suffer similar issues. Files will often be reduced to 720p or won't play at all, or there can be issues with audio and that's before we even start talking about 4K playback. An HTPC can play pretty much all your files and store them all locally – at the moment, no other device can do the same. However, the likes of Chromecast, Plex, NAS enclosures and smartphones aren't designed to work separately, but together, streaming, transcoding and using the Internet to get at the content you need. So, are there any combinations out there that can usurp an HTPC?

NAS enclosures

As most NAS enclosures lack any kind of video output, they're at the mercy of third-party apps and hardware to get your content onto your big screen or through your speakers. The Digital Living Network Alliance (DLNA) standard allows various devices from media streamers to smart TVs to access your NAS and play its media content. Such a setup works well from a sofa in your living room – the menus are all tied into your TV screen and there's no need to fiddle around with a gaming PC in the next room, a laptop or any other device – just your TV or streamer's remote control. Most consoles also support DLNA, so even if you don't have a media streamer or DLNA-enabled smart TV, you may still be able to make use of this standard.

Many modern NAS enclosures support Chromecast too. For example, Synology's smartphone DS Video App not only transcodes video on the fly, but you can push your NAS content to your TV using a Chromecast dongle over Wi-Fi as well. You do need a smartphone or tablet to use this feature, but most of us have these devices now. A bigger potential pitfall, however, is that Chromecast doesn't support 4K video playback, even with the latest model. Conversely, an HTPC can handle 4K video with one hand tied behind its back, as long as your video output and TV are compatible.

NAS enclosures also support a variety of media servers, such as Plex, which can work similarly to various NAS media servers such as Synology's DS Video. Again, you can control them using the Plex app on your smartphone (Android and iOS), from the Plex Web App in a browser or from some smart TVs.

Plex's output quality depends on the client you're using, though, both for video and audio. Mobile and web apps will likely transcode high-quality formats to low-quality ones (FLAC to MP3 for audio files on Plex, for example). Sometimes, you can force Plex and other servers not to transcode, but it isn't always possible. Finally, if you're coming from Windows Media Center and want a way to record live TV, many NAS enclosures support USB TV dongles. You can see Synology's list of compatible devices at http://tinyurl.com/synology-tv

Many NAS enclosures support USB TV dongles

NAS verdict

As with most other devices, a NAS is pretty useless on its own, but it will work well with DLNA devices such as consoles and Smart TVs. Failing that, Chromecast makes a great addition, as do media servers such as Plex and media streamers such as the WDTV Live. However, there are plenty of drawbacks, such as file support and very often, the inability to play 4K video content at the same quality, as it's stored on your NAS. There's also no way to access streaming services without other devices.

Chromecast

For the most part, Chromecast is brilliant. You get a small HDMI dongle, stick it into your TV, and you essentially have a tiny media streamer that can access the Internet and play local content. For streaming services such as Netflix, Chromecast is certainly far easier and quicker to use than

Stick the small HDMI dongle into your TV, and you essentially have a tiny media streamer

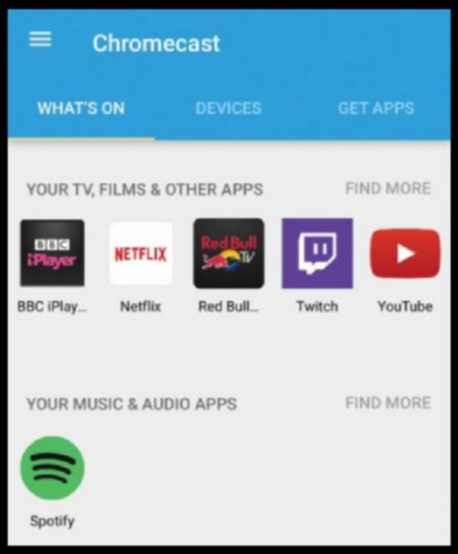
on an HTPC, although once again, the device is pretty pointless on its own. Android and iOS devices connect to the dongle and essentially point it at the Internet – for example, in the Netflix apps, tapping the little Chromecast icon while viewing content sends the location for it to the Chromecast.

There are a number of apps available for the Chromecast too, some of which, such as Videostream, allow for wide varieties of file formats to be played, while others connect to streaming services and websites – everything from TED talks to Red Bull and YouTube.

The downside is that you'll need to install apps for all these services onto your mobile device to be able to point Chromecast at the relevant URL. Sadly, however, accessing these websites in Safari on an iPhone, for example, doesn't give you the option of using Chromecast – you have to use the relevant app. On an HTPC, you could have all these websites in different browser tabs or as bookmarks, in addition to all your favourite streaming services.

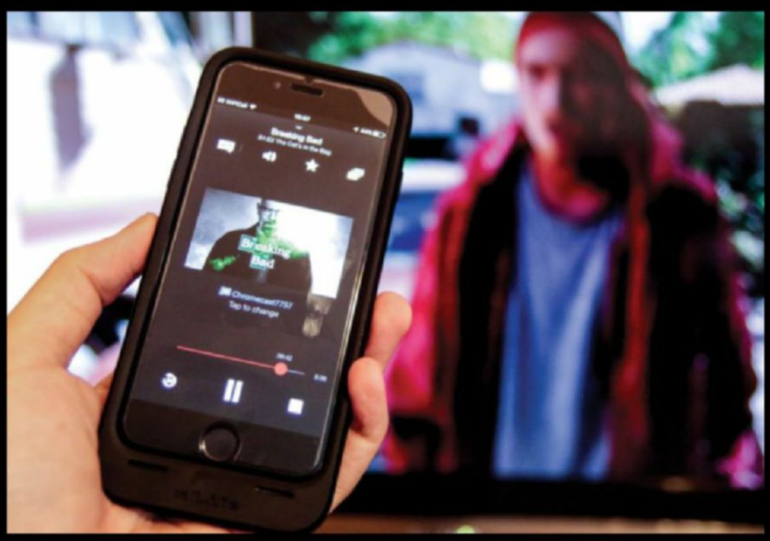
Chromecast also has another limitation that's likely to infuriate anyone who is happily breaking their Netflix licensing agreement by using a VPN to access Netflix's hidden treasure trove of content on its US server. When you link the Netflix app on a mobile device to stream on Chromecast, your Chromecast won't actually use your mobile device's Internet connection to access the content. In fact, it isn't even going to the same address – it uses Google's on servers by default, bypassing any VPN you may have set up on your mobile device. There are no VPN's available for Chromecast, and the only way of forcing it to use the server provided by a VPN is to hack the device itself (which usually isn't possibly if you've already connected it to the Internet anyway), or by blocking Google's IPs on your router.

However, only some routers let you block these IPs, and the procedure is pretty complicated, plus you'll be interfering with other devices that connect to the same network, as well as blocking UK content on Netflix. On an HTPC, though, if you're comfortable with the licensing implications, using Netflix over a VPN is blissfully easy. All you need is a Chrome browser plug-in such as Hola, and switching between UK and US servers is as easy as a single mouse click. Bear in mind, though, that Netflix has been talking about shutting down UK accounts that continually access the Netflix US service over a VPN, and it breaks the Netflix terms of use, so you do so at your own risk.



Chromecast Apps connect to many streaming services and websites – everything from TED talks to Red Bull and YouTube

In addition to Chromecast, Intel's Compute Stick makes for a compelling Windows-based alternative that could solve many of Chromecast's shortcomings. You'll need to use a wireless keyboard and mouse, so the interface isn't quite as slick, but if you don't need a monstrous HTPC with lots of local storage, or if you already have a NAS, it could make for a great, space-saving, low-power HTPC. The problem, though, is that the current version has been plagued by issues, such as poor Wi-Fi, and flaky wireless keyboard and mouse performance. A new Core M version is set to land soon, though, which we hope will solve these issues.



Android and iOS devices connect to the dongle and essentially point it at the Internet

chromecast verdict

As a bare minimum you need an Android or iOS device plus all the apps you'll want to use to access your content, such as Netflix, iPlayer and YouTube, all connected to the same network, with the Chromecast connected over Wi-Fi. To play local content, you'll need a NAS that supports Chromecast via its mobile apps, or a PC or laptop with a Chromecast plugin installed in your browser – again connected to the same network. Using VPNs is extremely difficult at best, there's no 4K support, there are some file and format compatibility issues, and playback can sometimes take a while to get going.

smart TVs

While Chromecast essentially turns your TV into a fairly capable smart TV, it isn't quite as streamlined as the real thing. The latest smart TVs support a considerable number of streaming services, as well as providing basic browsing functions and access to popular apps such as Skype and Facebook. All they need is an Internet connection – unlike Chromecast, you don't need a PC or a smartphone.

As usual, there are some drawbacks. Depending on when you bought your smart TV, and which model you own, it will be capable of doing different tasks. For instance,

installing third-party apps from the likes of Synology on Samsung TVs made in 2013 and later simply requires a USB stick and installation file. Devices made earlier than that, or TVs from other manufacturers, will be unsupported or require a more complicated setup procedure.

In addition to wide-ranging streaming service support, many smart TVs also offer DLNA support so you can access your content from compatible devices such as NAS enclosures. Also, many NAS manufacturers offer apps specifically for certain smart TVs that offer a specific service for dealing with video or audio files.

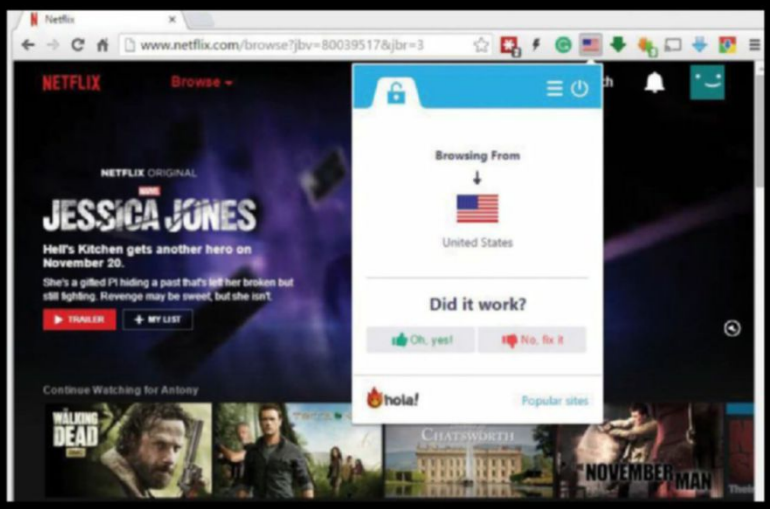
Sadly, though, in many cases, you're not able to transcode video using your NAS device's hardware-based acceleration, so it will depend on the model of NAS you own as to whether you'll be able to transcode videos on the fly or if you'll need to convert them first. Format compatibility is still an issue with smart TVs too. The range of supported formats has certainly increased, but both newer TVs and newer versions of the various operating systems available still have issues with some file formats, especially MKVs.

The latest smart TVs provide streaming services, basic Web browsing and popular apps such as Skype and Facebook

Similarly to Chromecast, getting VPNs working on smart TVs can be a minefield too. There are no VPN apps and networking controls are often restricted, meaning the process of setting up a VPN is either extremely complicated or a no-goer from the start. One of the easier ways of getting around this issue, as we mentioned earlier, is to use your router, perhaps with its VPN function – a feature that's available on some high-end models, such as Asus' AC68U. Another workaround is to fiddle around with the settings on the smart TV itself.

However, both these methods have two major drawbacks. Using your router's VPN function, or a similar feature, forces every device on your network to use it too. As such, while it will enable you to access content from another region, UK-only services such as iPlayer will be blocked. Switching between countries will mean logging into your router again and switching countries, which is a bit of a faff, especially if you're on the couch.

VPN services such as the Hola plugin work brilliantly on desktop browsers, but there's no way to use them as easily on a smart TV



Changing your DNS settings on a smart TV to those of a VPN provider (if you can do this and it works) is an even bigger faff, plus it's highly likely that all the native apps for your official region will be deleted too. So while a smart TV looks as though it can offer many of the features of an HTPC, there are still plenty of holes once you dig a little deeper.

smart TV verdict

Smart TVs are among the most self-sufficient HTPC alternatives, and they work brilliantly from your sofa. They can also make use of various local storage devices, support all the major streaming services and offer a modicum of web browsing and gaming too. However, they're not as flexible as a Windows PC when it comes to advanced features such as VPNs, dealing with file formats and 4K video files, and can't store any large amounts of data themselves either.

Our top HTPC hardware

Our conclusion, then, is that if you want the best flexibility when it comes to viewing and streaming content, and handling your data, the HTPC is still better than any combination of smart TVs, NAS enclosures or HDMI dongles, although this situation may well change a few years down the line. So what do you need to assemble a capable media rig?

Firstly, if you already own a laptop, you can easily combine it with Chromecast and get a fair amount of features while saving money. Likewise, if you have a PC, you can use it to tap into the various excellent media servers, such as Plex and Kodi. If you're still looking for a dedicated PC, though, there are other options to consider, such as an Intel NUC or a whole new build.

For our HTPC, we focused on low power consumption, small size and storage space, taking advantage of an SFX PSU and a mini-ITX motherboard. The resulting PC we built was quiet, good looking and able to playback 4K video with no problems.

CASE AND PSU

Lian Li PC-Q09FNB / £110 incVAT

SUPPLIER www.overclockers.co.uk

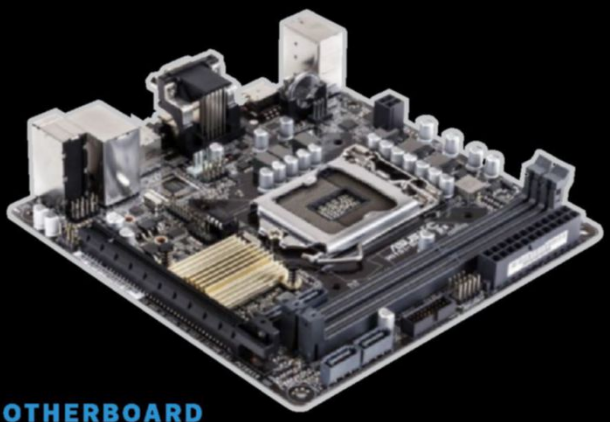
The case is perhaps the most important consideration with an HTPC. It needs to look unobtrusive in the lounge, and be as small as possible, but also provide enough cooling for your hardware. Ultra-slim cases aren't ideal for use in small areas and often use noisy PSUs, have no 3.5in drive bays and have loud cooling too. We've chosen Lian Li's new PCQ09FNB, which supports mini-ITX motherboards. It comes complete with an FSP 300W SFX PSU, plus you get Lian Li's famed aluminium construction all for just £110. It has a slim optical drive mount, USB 3 ports, a CPU cooler height limit of 50mm, plenty of room for SSDs and hard disks, plus an all-important 120mm side fan, which is intelligently installed as an exhaust.

CPU

Intel Core i3-6100T / £96 incVAT

SUPPLIER www.overclockers.co.uk

Minimising heat is key if you want to keep your HTPC's size to a minimum, which currently means opting for an Intel system. We weighed up the prices of going old school with a Haswell system, but opting for Skylake at the low end actually makes little difference to price. We opted for the Core i3-6100T – a low-power CPU with a TDP of just 35W, which costs practically the same as the older Core i3-4160T. This chip has plenty of grunt for transcoding using media servers such as Plex, and will have no problem dealing with streaming services or 4K video playback.



MOTHERBOARD

Asus H110i-Plus (DDR4 version) / £60 incVAT

SUPPLIER www.scan.co.uk

If you have a spare set of DDR3 memory, then you might want to consider opting for the DDR3 version of this motherboard. Otherwise, the two boards are identical. If you're buying a different LGA1150 board at the cheaper end of the scale, though, bear in mind that not all of them have HDMI ports or USB 3 headers. The Asus H110i-Plus has both these features, though, and a generous count of four SATA ports too.

MEMORY

8GB Corsair 2133MHz Vengeance DDR4 / £43 incVAT

SUPPLIER www.ebuyer.com

We had two options for memory – DDR3 or DDR4. There are two models of our H110 motherboard, with one using the former, and the other using the latter. As there wasn't much of a price difference, we've gone for the latest technology and chosen Corsair's twin 4GB DIMM set of 2133MHz Vengeance DDR4 RAM, so we can take advantage of dual-channel mode.

ELITE NEW ENTRY P60

CPU COOLER
Noctua L9i / £33 inc VAT
SUPPLIER www.scan.co.uk

Our CPU's TDP of just 35W doesn't demand much cooling, but an HTPC should be as quiet as possible. Therefore, we've opted for a premium low-profile cooler that won't end up being cramped inside the tiny case. Noctua's L9i measures just 37mm tall and its 92mm fan is blissfully quiet once it's hooked up to a PWM fan header.

SLIMLINE DVD DRIVE
Samsung SN-208FB / £14 inc VAT
SUPPLIER www.amazon.co.uk

We've opted for a simple DVD drive for our HTPC, on the basis that it will enable you to play all your old DVDs for just £14, while you can download and stream HD content. If you have an expansive Blu-ray collection, though, and you want to play your HD discs with your PC rather than a dedicated player, you can pick up a Samsung Blu-ray combo drive for £26 inc VAT from www.scan.co.uk

HARD DISK
Seagate Barracuda 2TB / £57 inc VAT
SUPPLIER www.ebuyer.com

If you aren't in need of any local storage, or you have a NAS, then you can skip the hard disk. If you want to store all your media locally on your PC, though, then the capacity to buy depends on your data needs. Stepping up to 4TB will set you back a little over £110.

SSD
Crucial 256GB BX100 / £66 inc VAT
SUPPLIER www.ebuyer.com

An SSD might seem like a luxury for an HTPC, but if you can stretch to an extra £60, it's definitely worth it. The system will be quicker to boot or resume from sleep than with a hard drive, and the OS will be much snappier too. Also, SSDs dish out less heat and are silent, whereas hard disks are comparatively hot and noisy. If you use a hard disk for storing your data, then it's well worth setting it to hibernate when not in use.

KEYBOARD
Logitech K400 Plus / £31 inc VAT
SUPPLIER www.dabs.com

The key to any HTPC is its input device, and your best option is a Bluetooth or RF wireless keyboard with an integrated touch pad. Using a mouse from your sofa is a pain – for quick actions on Windows to get to your desired content quickly, you need an all-in-one device. Logitech's K400 Plus fits the bill nicely. Its touchpad is responsive and the whole device is lag-free, has no connection issues and a range of up to 33ft/10m. Its battery life is also excellent, and its USB receiver is absolutely tiny – just make sure you don't lose it. CPC

Total cost: £510 inc VAT

GARETH HALFACREE'S

Hobby tech

The latest tips, tricks and news in the world of computer hobbyism, from Raspberry Pi, Arduino and Android to retro computing

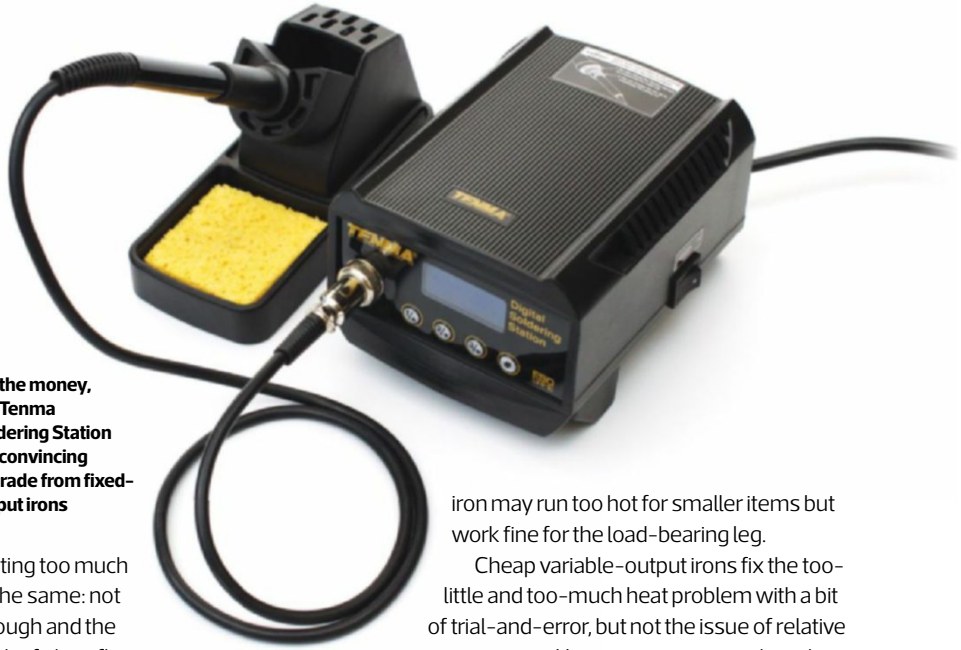
REVIEW
Tenma Digital Soldering Station

When I write a review it's usually based on relatively short-term usage of the product: I may have had access to the item in question for a day or two and used a battery of synthetic tests to make up for the short timescale, or I may have had it for a week or more and been able to get some real-life usage data. This time, though, I've been using the Tenma Digital Soldering Station since March last year.

For years I'd been using bargain-basement, fixed-temperature soldering irons, and when I finally upgraded to a variable-output model, it was Maplin's cheapest rebranded Chinese import. It served me well, despite its limitations, but after seeing an offer on a proper temperature-controlled soldering station, I was convinced that it was finally time to upgrade.

Of course, if you're a hobbyist, you almost certainly don't *need* a temperature-controlled digital soldering station. Need, though, is relative – and with this Tenma unit demanding a mere £20-ish premium over a good quality fixed-output iron, there are some reasons to consider it.

The first is how well it holds its temperature. Two killer problems when it comes to soldering are not getting enough heat and getting too much of the same: not enough and the solder fails to flow properly, giving you bad-quality joints; too much and you risk damaging the PCB or components. Worse, the temperature of your iron is relative: the larger the area you're soldering, the more heat it will suck away from the tip. A 25W iron will happily solder a small pin into place, but not a load-bearing leg. Conversely, a 60W iron may run too hot for smaller items but work fine for the load-bearing leg.



For the money, the Tenma Soldering Station is a convincing upgrade from fixed-output irons

Cheap variable-output irons fix the too-little and too-much heat problem with a bit of trial-and-error, but not the issue of relative temperature. However, stations such as this Tenma unit constantly monitor the iron's temperature, adjusting their output to keep it stable so, in theory, they bring an end to temperature-related soldering problems.

That's the best of the features, from a hobbyist perspective: it makes soldering easier. Another big selling point is a large display on the control box with buttons that

The iron's tips come in a variety of sizes and are easily replaced and reasonably priced at around £3 a throw

You might not need to switch between three temperatures, but the readout is certainly reassuring

The sponge is the weakest part of the bundle, but it's easily replaced at a very low cost

The iron is light and comfortable to use, but place it in its stand carefully if you don't want any accidents

enable you to choose the iron temperature from three settings, or adjust the settings directly. Once you find the best temperature for your solder, though, you're unlikely to touch these settings. The live feedback of tip temperature is handy, however, especially when powering you switch it on. There's no need to poke the tip with solder to see if it's hot enough to begin soldering, as with traditional irons, and the 60W output means the iron heats up quickly as well.

Not everything about the Tenma station impresses, though, which is hardly surprising given its low cost. The stand is pretty poor, as the iron weighs so little (a feature of having the heavy electronics located in the separate base, which links to the iron via a multi-pole connector with a metal retaining ring) that it's constantly threatening to be dragged down and out by the weight of its own cable.

The sponge, too, is of low quality: it's small and thin, and while it works, I'd advise ditching it in favour of a thicker sponge or – better still – some brass shavings, which have the added bonus of requiring no water.

In the year and more that I've been using the Tenma station, though, those are the only major issues I've encountered. It's always performed well, and I'm only on my second interchangeable tip, despite doing some heavy soldering work. The tips are also readily available in a variety of shapes and sizes for around £3 a throw, for when you've worn through one or need a tip that's better suited to a particular task.

The promise of electrostatic discharge (ESD) protection is reassuring too, especially when soldering directly onto semiconductors – although I've never lost a component to ESD yet, regardless of what iron I'm using.

If I were Tenma, I'd bundle a better sponge, tweak the stand's design, and give the base unit a removable IEC power lead instead of a fixed flying lead, to make transport and storage easier. Also, while I was at it, I'd swap out the power supply circuitry to be 110V/240V friendly, as it's currently only suited to one grid type, making it less useful for the hacker on the move.

Doing so, though, would likely increase the cost, and at £46.76 inc VAT, and frequently dropping lower during sales and offers, the price is the biggest selling point for the hobbyist market at the moment.

The Tenma 60W Digital Soldering Station is available to buy from etailer **http://cpc.farnell.com**, product code SD01738, with spare tips costing from £2.99 and a whole replacement iron unit available for £12.42, product code SD01891.

NEWS IN BRIEF

Arduino and Intel Partner for Genuino 101

Intel has announced the impending launch of the first Curie-based product the hobbyist community is likely to want: the Genuino 101. Built in partnership with Arduino.cc – and to be sold as the Arduino 101 in the USA – the Genuino 101 replaces the usual Atmel microcontroller of an Uno-style Arduino with a Quark-based Curie module, giving it increased performance, more memory, an on-board neural network and Bluetooth Smart compatibility, as well as an integrated accelerometer and gyroscope. The board is due to launch globally early next year, priced at around $30 (around £20 exc tax).

TUTORIAL

Spark Core ultrasonic sensor

Motivate yourself to stand at your desk, rather than sitting at it, via automated public shaming on Twitter

During the move to my new office, I must confess to falling into the fad trap: I bought a standing desk. Not a full-time standing desk; I'm much too lazy for that. I bought a desk that converts from sitting to standing at the turn of a crank. The trouble, however, is that it turns out I'm really lazy indeed; without a good reason to do otherwise, I spend my time in sitting mode.

The solution? A Spark Core – now known as a Particle Photon thanks to a recent rebranding exercise – to publicly shame me. Don't have a sitting/standing desk? Try building this project with a different type of sensor – a pressure sensor on your chair, a motion sensor or even a weight sensor if you're trying to slim down – the principle remains the same.

1 Build the circuit

The easiest way to see my desk's current mode is to measure the distance between the surface and the floor or ceiling, and the easiest way to do that is with an HC-SR04 ultrasonic sensor. This device 'pings' out an inaudible signal and waits to hear the echo back; a bit of maths later and you have distance. I'm using the Grove Distance Ranger, which is a modified HC-SR04 design, but only because I couldn't find my plain old HC-SR04 anywhere.

There are two important factors to note with this otherwise simple circuit. The first is that not all HC-SR04s are equal: check the pin labels carefully, as they're frequently in a different order depending on the manufacturer. You only need voltage, ground and the echo pin; leave the trigger pin disconnected.

The other is that the HC-SR04 is a 5V device, while the Spark Core (or Particle Photon, if you've bought one recently) is 3.3V. That means you'll need to tap into the VIN (voltage input) pin, which is a straight 5V feed from the USB port.

You'll also need a way to drop the voltage of the echo pin before feeding it into the Spark Core. Thankfully, there's an easy and cheap way to do this job, using a voltage divider.

WHAT YOU'LL NEED

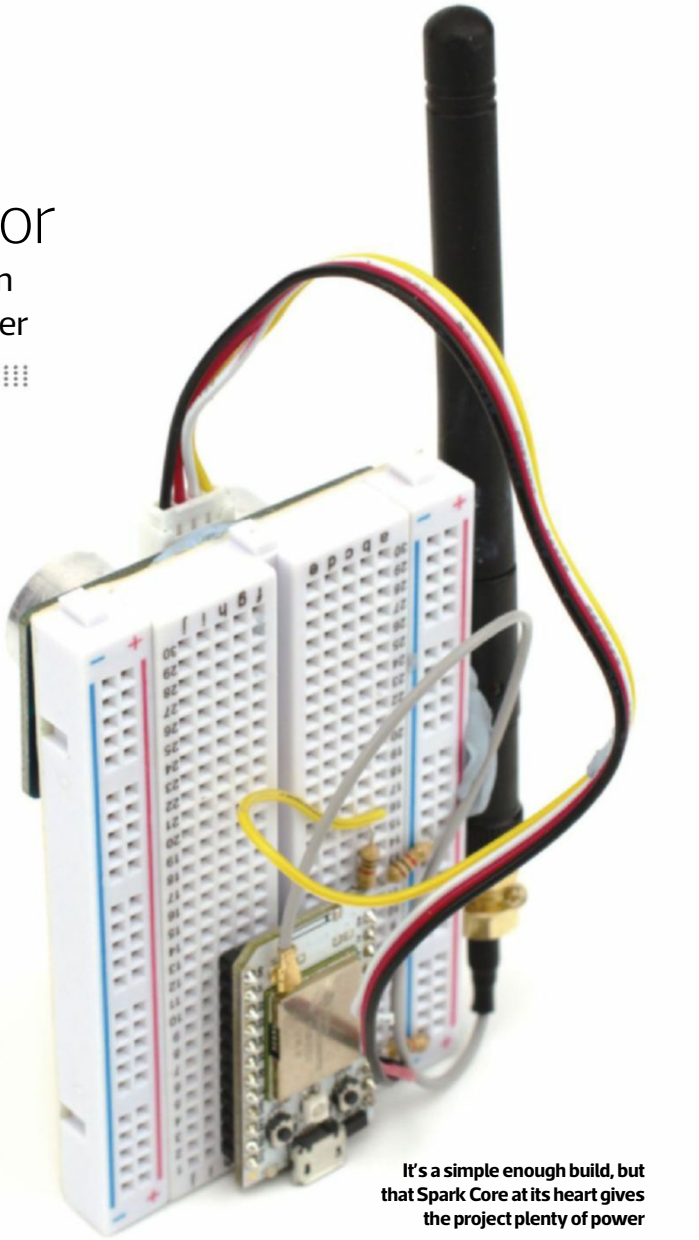
Spark Core/Particle Photon /
£19.99 inc VAT (http://is.gd/prtclphtn)

Mini breadboard /
£2.15 inc VAT (http://is.gd/brdbrd)

HC-SR04 ultrasonic sensor /
£3.73 inc VAT (http://is.gd/ltrsnc)

Jumper cables /
£1.79 inc VAT (http://is.gd/jmprcbls)

Three 1K resistors /
£0.60 inc VAT (http://is.gd/1krsstr)



It's a simple enough build, but that Spark Core at its heart gives the project plenty of power

Stick the echo lead from the HC-SR04 into the breadboard, and place one resistor between it and the Spark Core's input pin – I'm using A0, because it's closest to where I'm working.

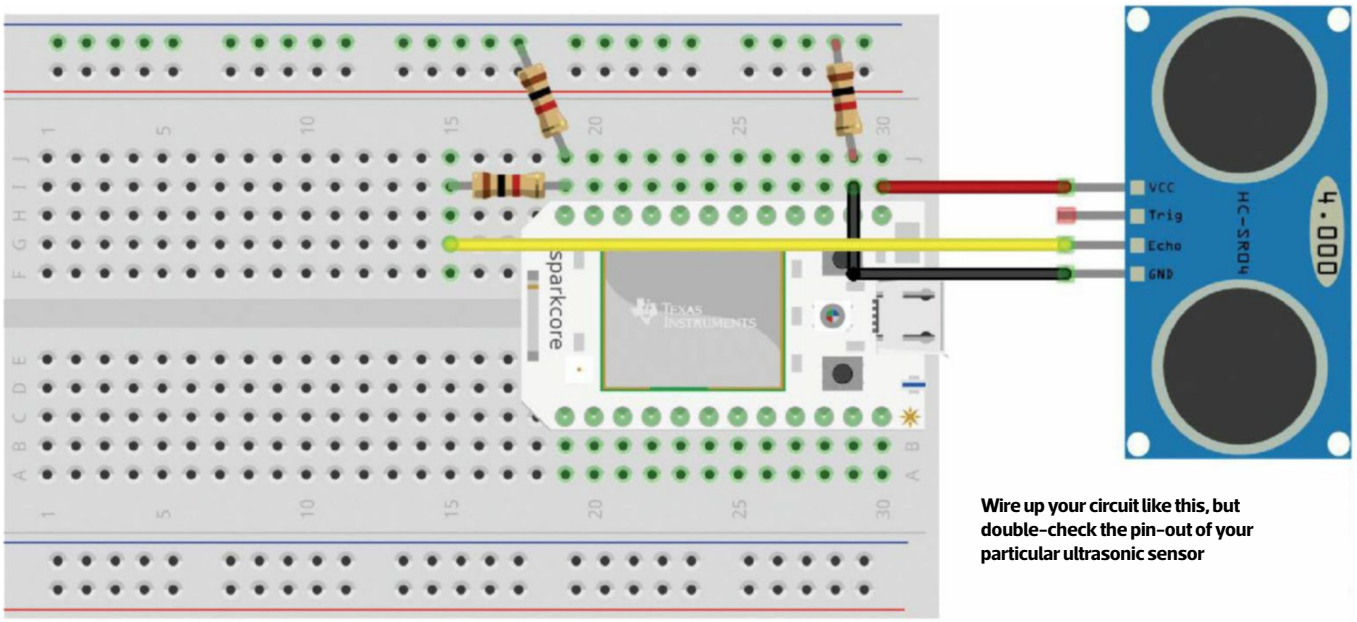
Take another two resistors of the same value, or one resistor of roughly double the value, and place them between the Spark Core's input pin and ground. Through magic that nobody outside an electrical engineering course needs to understand, the 5V output will drop to a Core-safe 3.3V as a result.

2 Program the Spark Core

If you've only just bought a new Spark Core or Particle Photon, follow the quick-start guide on the box to get it connected to your Wi-Fi network and assigned to your Particle account. Unlike Arduino devices and similar, the Spark Core is programmed entirely from your browser: there's no need to install any software or even connect the Core itself to anything other than power. Go to **http://build.particle.io** and create a new project with the following contents:

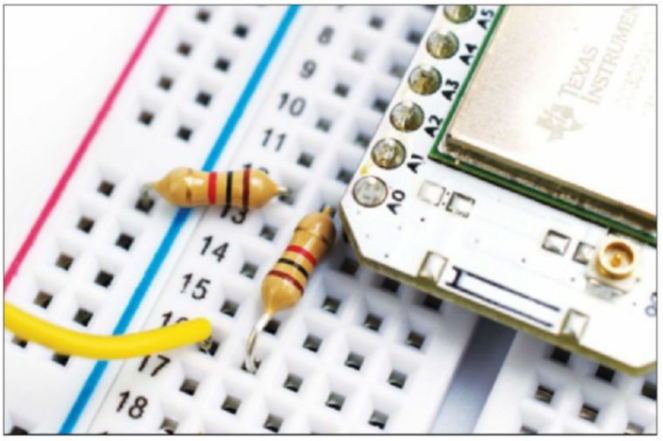
```
unsigned long echo = 0;
unsigned long ultrasoundValue = 0;
int ultraSoundSignal = A0;
int distance = 0;
int lastdistance = 0;
bool mode=0;
bool lastmode=0;
```

This symbol means the command should all be on one line



Wire up your circuit like this, but double-check the pin-out of your particular ultrasonic sensor

```
int matchcounter=0;

void setup()
{}

unsigned long ping()
{
   pinMode(ultraSoundSignal, OUTPUT);
   digitalWrite(ultraSoundSignal, LOW);
   delayMicroseconds(2);
   digitalWrite(ultraSoundSignal, HIGH);
   delayMicroseconds(5);
   digitalWrite(ultraSoundSignal, LOW);
   pinMode(ultraSoundSignal, INPUT);
   digitalWrite(ultraSoundSignal, HIGH);
   echo = pulseIn(ultraSoundSignal, HIGH);
   ultrasoundValue = echo / 58.138;
   return ultrasoundValue;
}

void loop()
{
   Spark.variable("distance", &distance, INT);
   lastdistance=distance;
   distance = ping();
   if (distance != lastdistance) {
      delay(1200);
      distance = ping();
   }
   if (distance == lastdistance) {
      matchcounter++;
   }
   Spark.publish("Distance",String(distance),60,
PRIVATE);
   if (matchcounter > 2) {
      matchcounter = 0;
      lastmode=mode;
      if (distance > 170) {
         mode=0;
      }
```



Those resistors are all that stand between the Spark Core and a fiery – or at least warm – death from 5V

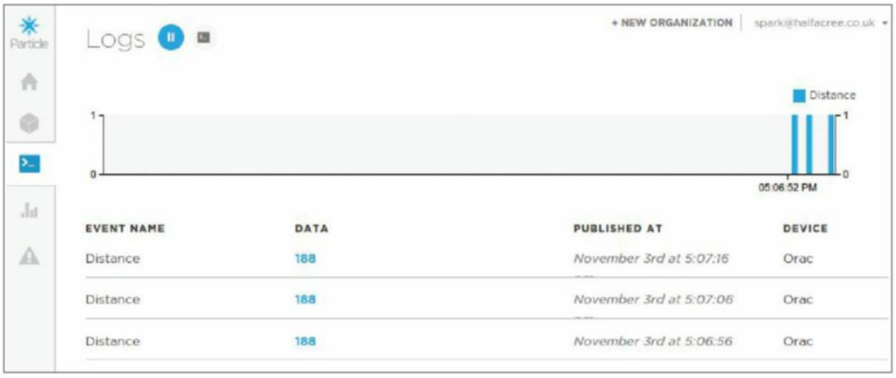
```
      else if (distance < 160) {
         mode=1;
      }
      if (mode != lastmode && !mode) {
         Spark.publish("Mode","sitting",60,PRIVATE);
      }
      else if (mode != lastmode && mode) {
         Spark.publish("Mode","standing",60,PRIVATE);
      }
   }
   delay(10000);

}
```

For a digital copy of the code with comments, head to http://is.gd/ltrsnccode. Hit the tick to verify the code, then hit the lightning bolt to pick your Spark Core and flash the chip remotely. Naturally, if you're not tracking a sitting/standing desk, you're going to need to edit some code first.

3 Check the data

The magic of the code all happens through the publish function, which takes whatever data you tell it and shoves it through the network to

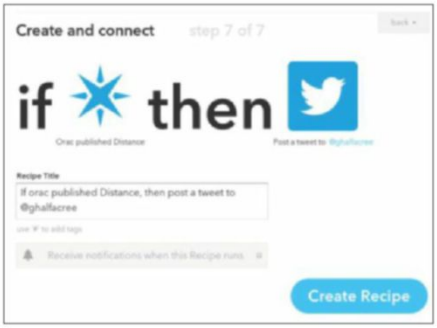
The Particle IDE runs entirely within the browser and flashes the Spark Core wirelessly



While still a work in progress, the Dashboard view lets you check that the sensor is working before proceeding

Particle's system. You can keep an eye on exactly what's happening by heading to **http://dashboard.particle.io**, which is currently in beta. Wait a few seconds once it's loaded, and you should see a publish event labelled 'Distance' pop up with a value equal to the distance from the sensor to the echoing surface in centimetres. Stick something over the sensor, wait ten seconds, and you should see the reported distance drop considerably.

This is really the Spark Core's killer feature – what would take a fair bit of messing and your own server to achieve with an Arduino and Wi-Fi shield takes one line on a Spark Core. Future Dashboard features include live graphing of incoming data, which will be handy, but I need more than a graph to get me off my backside.



Creating 'Recipes' in If This Then That is as easy as following the site's wizard, or building on someone else's work

4 The public shaming

I've built projects that post to Twitter before, and it's always been a pain, involving various libraries and setting up developer accounts. Thankfully, that isn't necessary here, thanks to a handy service called If This Then That, which does exactly what it says on the tin: it waits for something to happen, then it makes something else happen.

Head to **https://ifttt.com** and sign up for an account, if you don't have one. Head to the Channels section, and search for Particle.

If all has gone well, your sensor can trigger messages to Twitter through the IFTTT recipe

Click on Connect and log in to the Particle website with your username and password. This system links your Particle and IFTTT accounts, and allows you to track any and all of your Spark Cores and Particle Photons within IFTTT. Do the same with the Twitter channel.

To replicate my public shaming, you'll need to use the Recipe wizard. Go to My Recipes and click on Create a Recipe. Use the following steps: click 'This' and find the Particle channel; choose New Event Published; use the Event Name 'Distance', select your Spark Core or Particle Photon before clicking on Create Trigger; click 'That,' find the Twitter channel, and click on 'Post a tweet'; edit the text to read: 'The desk switched to {{EventContents}} mode' or something similar; click on Create Recipe.

With that, you're done: every time your Spark Core detects a distance change, it will publish the fact. This publishing is picked up by IFTTT, which will send a Tweet onto your linked account accordingly. Be careful while playing with this feature though – people don't take kindly to a flood of automated messages. If you're planning to use such a setup over a long period, consider setting up a dedicated Twitter account for the project.

While you're on IFTTT, play around with some of the other channels: you can link your Spark Core to other social networks, track its raw data in a Google Docs spreadsheet for graphing and more. Considering its simplicity, it's a very powerful tool. **CPC**

NEWS IN BRIEF

Amazon Launches AWS IoT beta

Amazon Web Services, one of the cloud computing strings to Amazon's bow, now has a special tier just for Internet of Things (IoT) projects. Unimaginatively named AWS IoT, the new service offers a managed cloud platform that can communicate with IoT devices via HTTP or MQTT. It also offers developers a way to build a cloud-connected IoT platform without needing their own servers. The company offers a free tier suitable for hobbyists with 250,000 messages per month, while pricing additional messages at $5 US per million.

Gareth Halfacree is the news reporter at www.bit-tech.net, and a keen computer hobbyist who likes to tinker with technology. @ghalfacree

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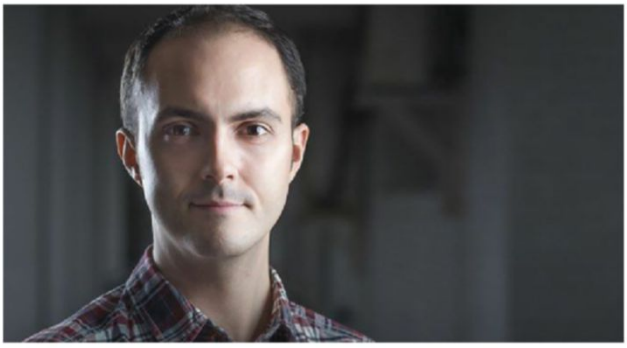


ANTONY LEATHER'S

Customised PC

Case mods, tools, techniques, water-cooling gear and everything to do with PC modding

Mini-ITX cases need a rethink

There are some fantastic mini-ITX cases that cater for all manner of systems, but the performance gaming area of the market is currently coming up short. My grumbles began when Nvidia's GTX 660 and 670 graphics cards began sporting deliberately shortened PCBs.

These cards meant you no longer needed a large case to accommodate them, or one that offered enough room to house a decent mid-range GPU. The situation has progressed even further since then, and currently, the GTX 960 and awesome GTX 970 are available in decidedly dinky variations, plus AMD has its new R9 Nano. The issue, however, is that very few (if any) cases take advantage of them.

It's an issue that reared its head again when our columnist Richard Swinburne mentioned to me on Twitter that the awesome EKWB Predator all-in-one CPU cooler we reviewed last month was exactly the same length as a mini-ITX motherboard and an SFX PSU. Of course, with short PCB GPUs being the same length as the motherboard, there's the option to make a case that houses all of this kit without wasting space. You don't see this space optimisation with the latest mini-ITX cases, though, for several reasons.

Small-PCB graphics cards have great potential for making tiny mini-ITX rigs, but few cases take advantage of them

While many mini-ITX cases from the likes of Phanteks offer great water-cooling support, they also use standard ATX PSUs

While many cases, such as BitFenix's Prodigy or Phanteks' mini-ITX offerings, offer great water-cooling support, they also use standard ATX PSUs, which are mounted at the rear of the case as usual.

As a result, there's often a huge gap at the front of the case, so the chassis ends up being larger than necessary. Even SilverStone – a strong supporter of the SFX PSU form factor – lacks the winning combination. The FT03 Mini sports an interesting use of SFX PSUs and mini-ITX motherboards, but it also supports GPUs in excess of 250mm and is one of the worst cases for water cooling available. Most small cube cases such as Parvum System's X1.0 support large graphics cards too.

Likewise, Lian Li's PC-Q07, which supports GPUs up to just 180mm long, still uses a space-wasting ATX PSU that's annoyingly located over the top of the motherboard, obstructing access to it. The case also has practically non-existent water-cooling support, although on the plus side, it's very short, with a depth of just 20cm. It's a shame, then, that case manufacturers aren't taking advantage of all the options – a full combo with an SFX PSU, mini-ITX motherboard and short GPU could be very small indeed.

That might sound like a niche build, but with AMD's R9 Nano blazing a headline-grabbing trail for short PCBs, I'm hoping that case manufacturers will take some notice.

We don't all need masses of space for graphics cards; many people don't need more than an SFX PSU and mini-ITX motherboards are more popular than ever. It's high time we got a case that takes advantage of all these new benefits – there are already plenty of projects that do so in the PC modding scene.

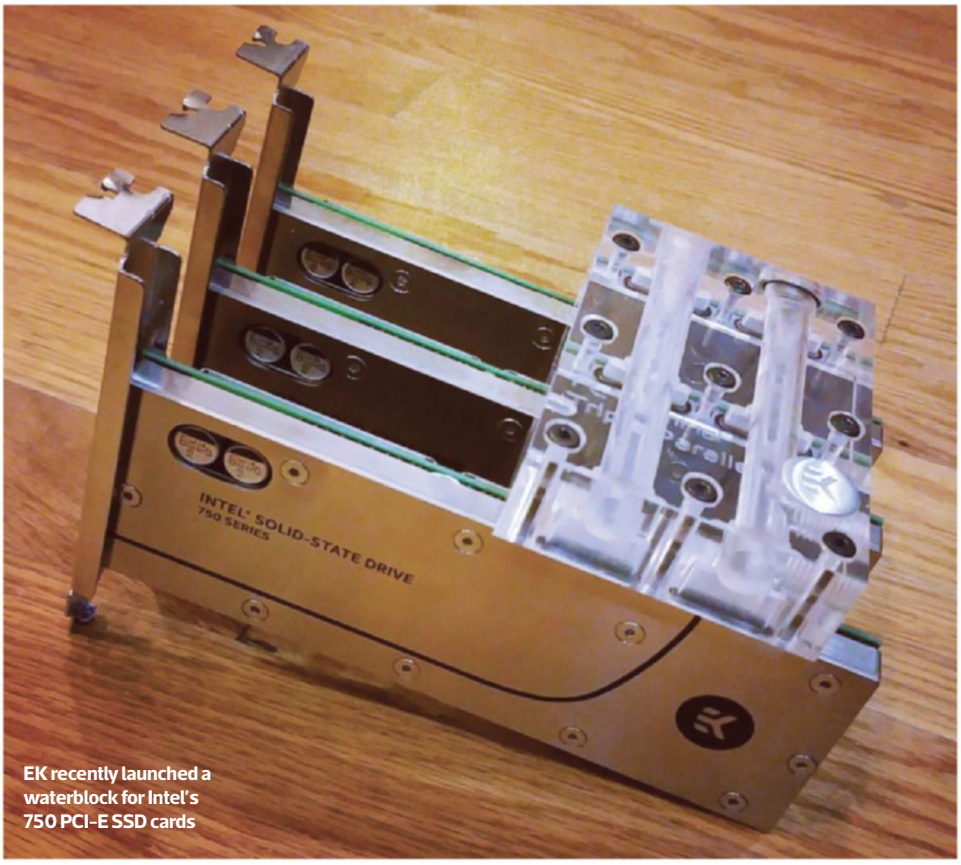
An interview with EKWB

Following our review of EKWB's Predator 240 all-in-one liquid (AIO) cooler last month, I spoke to EK about its latest gear, including a waterblock for Intel's new SSD 750.

Antony: What made EKWB consider making an all-in-one liquid cooler?
EKWB: We felt that there was a gap in the market between the low-end all-in-one liquid coolers and DIY water cooling. There are probably hundreds of sealed AIO coolers, and the options become even more overwhelming when considering open loop cooling. We alone sell around 600 active SKUs. The Predator was meant to bridge the gap between a classic AIO cooler and custom loop cooling. This way, a customer can have the convenience of an AIO cooler, but with the option to expand to a custom loop when they're ready, without having to throw away or attempt to sell their old cooling system.

Antony: Do you see the Predator attracting water-cooling newcomers or experienced water-cooling fans that want a simple setup, or both?
EKWB: We see the Predator attracting both crowds, especially as the industry seems to move towards an emphasis on smaller machines. We've had lots of customers ask us if they can only purchase the radiator, fans and pump combo unit to use in their custom loops! It's a very convenient system and, as it uses off-the-shelf, enthusiast-level components, it's attractive to all customers.

Antony: Is the pump powerful enough to handle full expansion, such as upgrading to a bigger radiator, and adding GPU and motherboard blocks?
EKWB: Our 'official' recommendation about what the pump can handle is as follows: one CPU, two GPUs and two radiators. Pumps are largely underestimated in the custom loop cooling industry. I've seen builds with eight blocks and six radiators powered by a single Laing DDC pump! The DDC in the Predator is the most powerful pump on the AIO market, and it can handle expansion with no problems.



EK recently launched a waterblock for Intel's 750 PCI-E SSD cards

Antony: Do you have any plans to release a single-fan radiator Predator, or models with140mm fans?
EKWB: While the sizes haven't been finalised yet, I can say that there will be more models available in 2016.

Antony: With regards to your new waterblock for Intel's SSD 750, has EKWB made any other hard disk or SSD waterblocks?
EKWB: This is our first venture into making a waterblock for a storage device. We've received a lot of positive feedback about the block, and we look forward to expanding the line-up.

Antony: What prompted you to make a waterblock for Intel's SSD 750 card?
EKWB: The Intel 750 series pushed enthusiast-level storage devices to a new level, which we appreciated. SSDs have been getting faster every year, but over the past few years, we've seen pretty small increases overall; the 750 drives with NVMe tech changed this situation. Intel is making an effort to tap into the extreme enthusiast market with these drives, and we wanted to be a part of it and release something equally extreme that would give high-end modders one more exciting product to play with.


EK already makes double and triple 120mm-fan radiator versions of the Predator – more sizes are due next year

Antony: The card obviously doesn't *need* to be water cooled, but does it get hot enough to see a benefit from extra cooling? Or is the block more of a showpiece for extreme PCs?
EKWB: These aren't your average 2.5in SSDs that are famous for producing no heat at all. A 750-series card in between several high-TDP GPUs can get quite toasty. The waterblock is mostly for the awesome factor, but in low-airflow environments, you may see a benefit in terms of performance and the lifespan of the drive.

Antony: How much does the Intel 750 waterblock cost?
EKWB: The Intel 750 waterblock is currently available for $99.99 [around £67]. CPC

Antony Leather is Custom PC's modding editor @antonyleather

How to Create straight PSU cables

Do you obsess over the neatness of your PSUs cables? Antony Leather shows you how to achieve great straight lines

TOTAL PROJECT TIME / 24–48 HOURS

There are a number of ways you can mod your PSU cables. You can replace them entirely with a pre-braided cable kit – there are loads of colours from which to choose and many companies such as CableMod cater for various modular PSUs as well. You can even buy extension cables if you have a captive-cabled PSU. However, there are few ways to actually make your custom cables look neat. You can use cable combs to even out the spacing, but you'll still need to bend your wires through routing holes and around other components.

If you're looking for the ultimate cable neatness, though, you can use thin acrylic tubing, which can be bent to shape using a hairdryer or, even better, a heat gun, as with normal water-cooling acrylic tubing. We'll look at how to straighten your PSU cables using this method in this guide, and also show you how to spray your tube-covered cables.

TOOLS YOU'LL NEED

Metal file / Most hardware stores

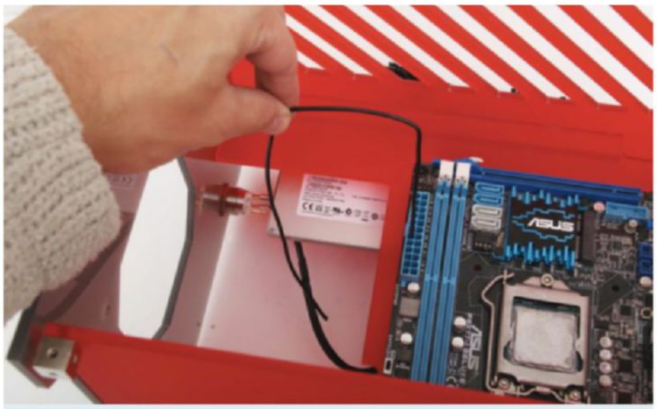
5mm/3mm tubing / www.hindleys.co.uk

Dremel or hacksaw / Most hardware stores

Industrial heat gun / Most hardware stores

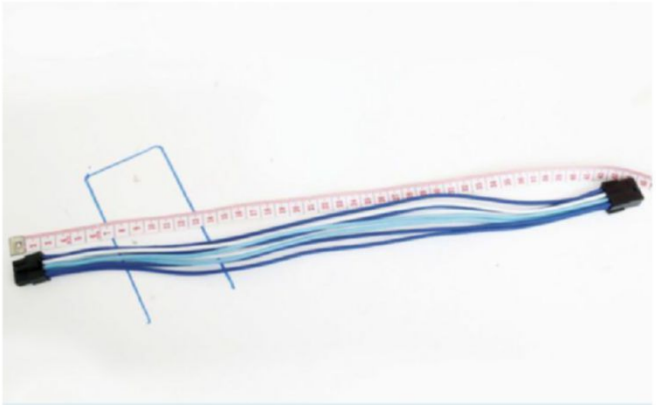
PSU modding toolkit / www.watercoolinguk.co.uk

Plastic primer, colour and lacquer paints / Most hardware stores



1 / WORK OUT THE ANGLES YOU NEED

As with water-cooling tubing, your first job is to work out the curves and angles you need to achieve to route your cables from place to place. You can use string to create a mock-up of your system.

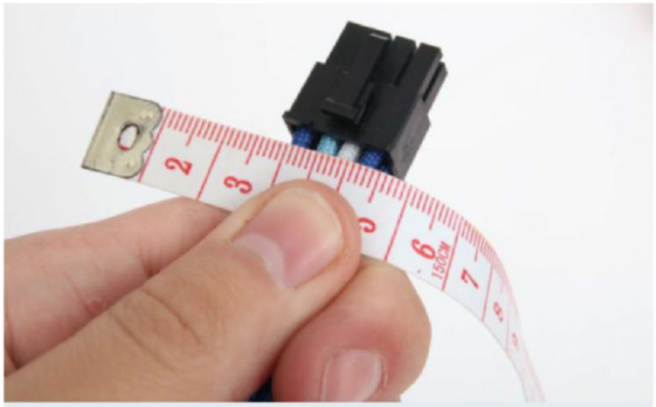


2 / MEASURE THE CABLE LENGTHS

It's easy to underestimate the length of acrylic tube you need – a single 30cm 24-pin ATX connector needs 720cm of tubing to cover all the cables. Count the cables you need to cover, but keep the tubing to a minimum to save costs – don't cover cables that will be out of sight.

3 / CREATE A TEMPLATE

You'll need a support or template to bend the tubing to the correct angle, as current tube bending tools won't work with multiple small tubes. A stiff cardboard or metal box is perfect for this job, or you could cut out a section of hard wood.



4 / MEASURE CABLE WIDTHS

You need tubing that can fit over your existing cables with as little work as possible – you'll be performing this job dozens of times to kit out a whole PC. We used 5mm acrylic tubing with an inside diameter of 3mm.

5 / CHECK TUBING WIDTH

You also need to consider the width of the acrylic tubes. You don't want them protruding over the edges of connectors, so make sure they'll sit within them. You may have to strip off the braiding on your cables, but the end result will still look much better.

6 / INSERT PIN REMOVAL TOOL

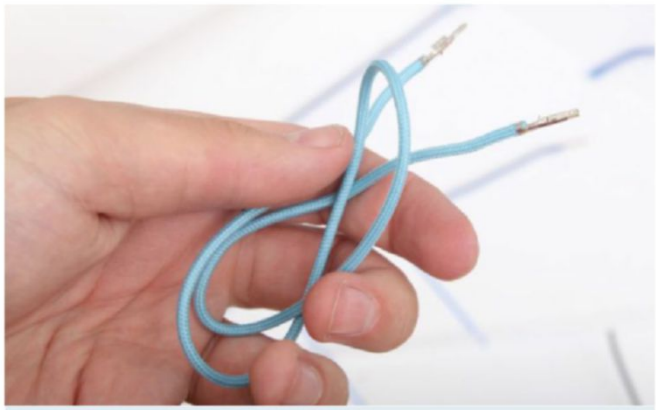
You'll need to use a PSU modding tool to remove the various cables from their connectors. With the motherboard and graphics card connectors, you'll need to insert the two-pronged tool around the outsides of the pin.

7 / REMOVE PIN

Using the tool in this way will push in the two metal flanges on either side that hold the pin in place. Pulling firmly on the rear of the cable should see it pop out. If not, reinsert the tool and try again.

8 / TRY USING TUBE

Some cables may allow you to slip on the tube straight away without any further work, depending on the thickness of the braiding and the tube you're using. If this works then thank your lucky stars, move to step 14 and continue working in this way with all the cables.



9 / REMOVE ENTIRE CABLE

If the cable is too large (ours was just too big for the 3mm hole), you'll need to remove the cable to trim it down a little – simply use the pin removal tool on the other end. All the connectors are the same, so you don't need to remember the order.

10 / IDENTIFY PINS

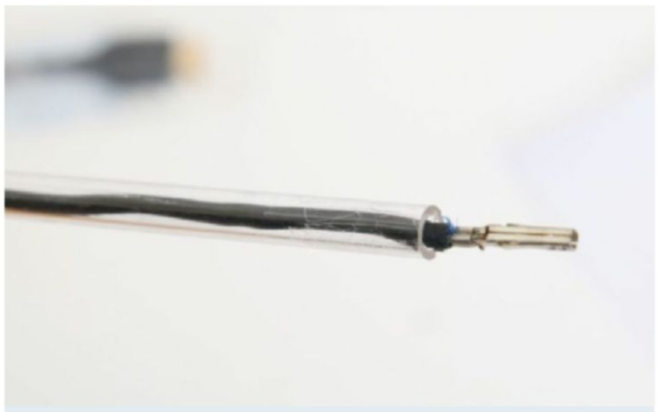
Firstly, identify the two different pin types. You need to work on the open-topped pin, which is on the right in this photo, and not the square-shaped pin on the left.

11 / FILE PIN-END FLANGES

The pin has two vertical flanges right at the back near the cable, not to be confused with the horizontal ones halfway towards the pin head. File down these flanges and the cable should now insert easily into the tubing.

12 / UNPICK SLEEVING

In rare occasions where the cable still doesn't fit into the tubing, you'll need to experiment further, first by removing the sleeving to shed some more width. Unpick the two clasps at the base of the cable and pull away the sleeving.



13 / REMOVE SLEEVING

You may need to file down the metal flanges further to remove the sleeving, or try cutting off the sleeving if it still gets stuck. You can also try compressing any flanges on the pin – hopefully, you'll now be able to insert the cable into the tube.

14 / MARK UP TUBING

Once you know the length of tubing required, mark up the acrylic tubing to the correct length. Don't score the tubing, as it will leave physical marks – use a marker pen instead; these marks will be covered by the paint later.

15 / CUT TUBING

Cut the tubing using a hacksaw with a fine cutting blade – a regular blade may cause the tubing to shatter. You can also use a Dremel with a cutting disc for cutting soft materials. Alternatively, if you own a rigid tubing toolset, it should come with all the bits you need for this job.

'With moments of real genius, some of his poems will last as long as poetry is read.'

– Benjamin Zephaniah

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Felix Dennis

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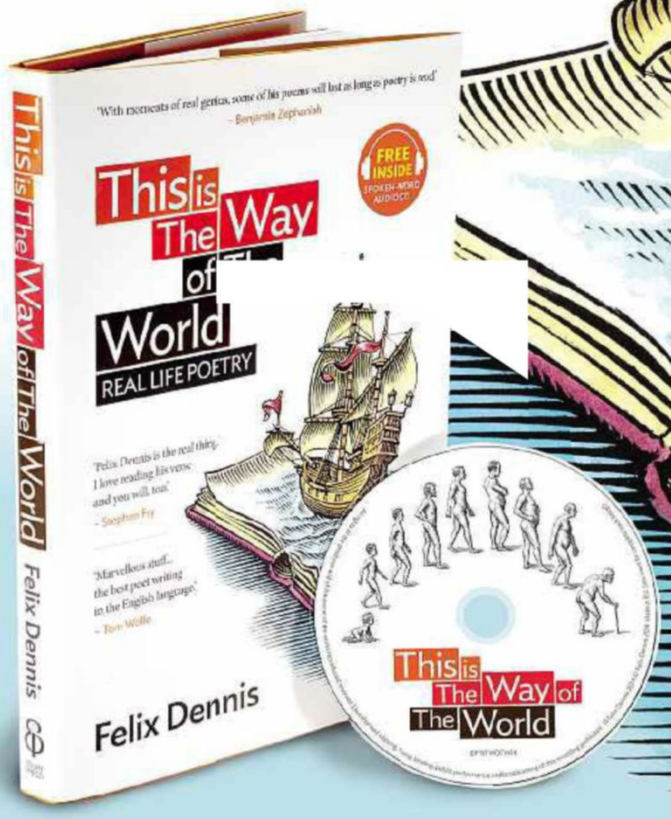


A book of poems for those who don't read poetry (as well as for those who do!)

A collection of 'real life' poems by Felix Dennis, one of Britain's best-loved poets, charting life's course from infant to endings with illustrations by Bill Sanderson.

www.felixdennis.com contains many poems, published and unpublished, as well as a library of sound recordings and video footage of Felix Dennis's verse and poetry tours.

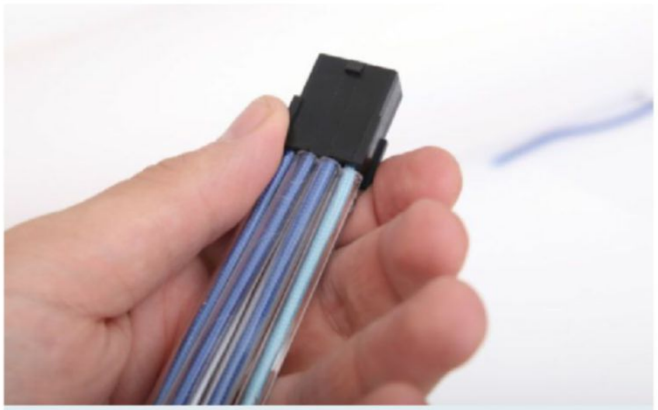
EBURY PRESS

16 / INSERT CABLES

Go ahead and insert all the cables into the lengths of tubing. Don't worry if any tubes are slightly longer than others – you won't be able to tell the difference once you've applied the plastic adhesive.

17 / LABEL CABLES

It's essential to wire up the connector correctly, and the best way to achieve accuracy here is to label each cable. Alternatively, you can mirror your work at either end, using the same slots on each connector.



18 / REATTACH END PIECES

The end connectors should just slot into place with some jiggling, but you may find you need to rotate each cable until it inserts in the correct way. Again, don't worry too much if they don't all line up perfectly, as the plastic adhesive will mask these flaws.

19 / MIX PLASTIC ADHESIVE

We've used UniBond plastic adhesive to fix the tubes to the end connectors. Mix a generous amount of the two-part adhesive together, as you'll need to cover the end of the connector.

20 / GLUE TUBES IN PLACE

Apply the glue to the connector and spread it in among the tubes at the base. The glue will hold the cables in place if there's any lateral force caused by the bent tubes, which could result in them being splayed out and looking unsightly.

21 / APPLY INDUSTRIAL HEATER

Move the heater across the tubes evenly and on both sides, but don't hold it too close. Eventually, you'll see the tubes becoming bendable. If you have trouble dealing with all the tubes at once, you can heat them individually.

22 / BEND AROUND SUPPORT

Using a support or desk end, bend the tubes at a right angle. It's easier to bend them in turn, heating the tubes again – don't attempt to do two bends in one go as the tubes cool quickly.

23 / MASK OFF CONNECTORS

To avoid paint getting onto the plastic connectors or pins, mask them off with duct tape or masking tape prior to painting. It's better to connect the cables to the connectors before painting, as reinserting them after they've been painted is a recipe for scratches.

24 / SPRAY WITH PLASTIC PRIMER

You'll need to use plastic primer first, so that the paints stick to the plastic tubing. You only need a single coat in order for an adhesive layer to be built up, which enables normal spray paint to stick to it.

25 / SPRAY WITH COLOUR COAT

Apply numerous thin layers of colour coat, and let each coat dry; the small round tubes make it very easy for the paint to run if you apply too much.

26 / APPLY LACQUER

Finally, apply the clear coat. You can use matt spray paint if you don't want shiny cables, but the lacquer will add a protective layer to guard against scratches. You'll need to apply three or four coats.

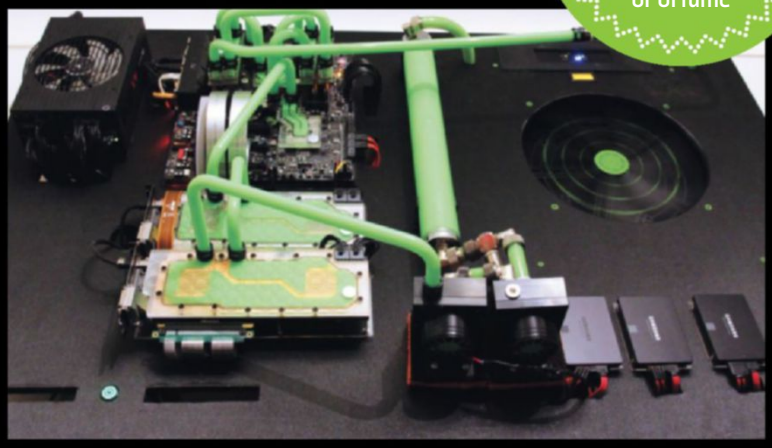
27 / ALLOW TO DRY

Lacquer generally needs 24 hours to fully harden, so leave the cables to one side for a day, ideally in a garage or outside, as the lacquer expels fumes as it dries. CPC

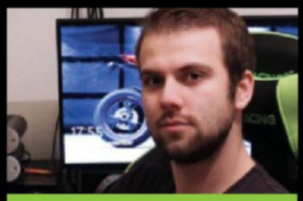
Readers' Drives

F.R.A.M.E

SEE THE FULL PROJECT LOG: http://tinyurl.com/CPCFrame



A keen DIY enthusiast and PC gamer, Ersan Uzunoglu decided to build a high-end PC that could be mounted on a wall like a painting



/MEET THY MAKER

Name Ersan Uzunoglu

Age 23

Location Inverness

Occupation Part-time Vodafone sales assistant/actor

Main uses for PC Gaming, home theatre, movie editing, music/audio production and almost everything else

Likes Playing games, riding my motorcycle, going to the gym, acting in film and theatre, swimming, doing extreme sports, Android phones, Marvel Universe (especially Ironman!) and building custom PCs!

Dislikes Football, rugby and every single Apple product

CPC: What originally inspired you to build F.R.A.M.E?

Ersan: I was inspired by Show4Pro's custom wall-mounted computer over at www.overclock.net a few years back, but I didn't want to attempt such a massive build at that point, as I wasn't sure if I had the required skills.

CPC: Where did the name come from?

Ersan: It's very simple. F.R.A.M.E is just like a picture frame, but instead of having an extremely exquisite piece of handpainted art inside it, there's an extremely expensive gaming computer mounted on a piece of wood. I only decided to add the dots between each letter in the name for aesthetic purposes.

CPC: What's F.R.A.M.E's purpose, and what specs did you use?

Ersan: The main purpose of this project was to build something unique and one of a kind. I'm very into DIY – I enjoy building and making things from scratch. I'm a huge PC gamer too – I spend most of my days in front of the computer.

'Why not just spend some money and put in some elbow grease to make something that's truly mine and unique,' I thought, so I researched some custom PC projects on Google.

I failed to find anything that grabbed my attention in this search, but then I remembered that wall-mounted PC I'd seen a few years back, so I examined that project and read the build logs thoroughly.

I didn't want to copy Sho4pro's wall-mounted build all the way; just the concept of it being mounted on a wall was enough to get me started. The computer hardware itself isn't new though – it came straight out of my previous build. I couldn't justify spending all that money on new components when my current specs are still extremely powerful.

CPC: What other mods have you built?

Ersan: This is my second scratch build. My first one was inspired by Peter Brands' L3P D3SK – the moment I saw his desk, I wanted one as well, so I made one. The purpose of that desk was just the same as F.R.A.M.E – wanting a unique, custom PC that I could be proud of making.

CPC: What difficulties did you come across?

Ersan: One of the biggest issues I came across was working out how on earth to get that SLI bridge across to the other card. No matter what I did, I just couldn't get my SLI bridge across – I even searched for extra-long SLI cables and DIY SLI cable mods. One of the latter I came across was made by someone who had soldered two cables together to make the bridge longer – I tried that, but it didn't work. I got pretty mad and ripped the cables apart.

By this point, I'd spent five days trying to figure out a solution to the problem, but I thought I was done and that I could no longer continue with the project.

Then, while I was searching eBay, I found a 15cm SLI bridge – the biggest I'd found – all the others I could find were 12cm long. So I bought this bridge and it arrived from the USA, but again, it almost reached, but didn't quite go far enough. I eventually measured some angles and worked out that, if I raised the bottom GPU higher than the top GPU, the SLI bridge would fit – problem solved!

Every time I build something, whether or not it's a computer project, I always end up learning how not to do something.

I suppose that's good in a way. It means that I have to spend some extra cash on replacing the part I

SYSTEM SPECS

CPU Intel Core i7-4930K overclocked to 4.2GHz

Graphics card 2 x Nvidia GeForce GTX 690 running in Quad SLI configuration

Memory 16GB 2400MHz DDR3

Motherboard Asus Rampage IV Black Edition

Storage 2 x Samsung 850 Evo 1TB in RAID 0 configuration, 1 x Samsung 840 Evo 250GB PSU Corsair AX1500i

Case Scratch build

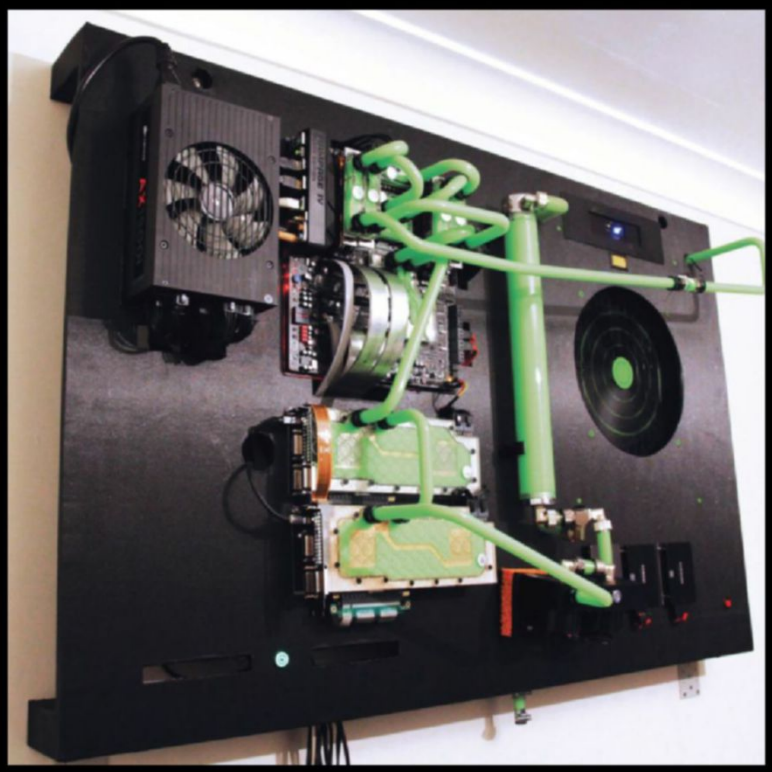
Cooling Custom water-cooling loop

messed up, but it's worth it in the end – it's just trial and error.

CPC: What materials did you use?
Ersan: I used clear acrylic to mount each component, and wood for the base unit. The top section, where all the components are held in place, is a large plywood sheet, and the sides that provide clearance from the wall to the board are made from pine wood. Obviously, the whole unit looks like it's made from one material, but that's because I wrapped it all in black brushed aluminium vinyl.

The reason why I chose wood over other materials was because of its surprisingly good noise and vibration-dampening properties. Wood is heavy and thick, and it destroys any resonating noise from fans and pumps. My aforementioned desk build was made from 100 per cent aluminium, and the resonating noise sounded like it would pierce my eardrums and start etching itself onto my skull. No matter how much noise-dampening material I used, the two pumps that powered my loop were always loud, but they're extremely quiet with this wall mount.

CPC: What tools and/or machinery did you use?
Ersan: Just your average household power and hand tools: a hacksaw to cut the wood, a chisel, a drill, a ruler and, of course, a Sharpie to mark it all out. I was going to use a large router at my friend's sign-making business to cut out a large circle for a 360mm fan, but the router hadn't arrived at this point and, as I was being very impatient, I hand-cut it myself – it isn't perfectly rounded, but I'm satisfied with it.



The fan itself is slowed down with a resistor so minimise the noise output, but still pass enough air through the radiator fins to cool the water.

I also made a dedicated on/off switch for the fan, which is placed next to the SSDs – I usually leave it off and only turn it on while playing GPU-intensive games. The radiator is a large Watercool Mo-RA3 420mm model, so it can be run passively at non-intensive workloads without an active fan.

CPC: How long did the build process take?
Ersan: I'd been planning and designing this project for around three months before I bought any materials to build it and dismantled my old PC. Once I took everything apart, it took me around one month to complete the build – if I hadn't run into unexpected problems, such as the SLI bridge issue, I'm guessing it would have taken me half the time.

CPC: Are you happy with the end result, and is there anything you'd do differently if you built it again?
Ersan: Overall, I'm very satisfied. There are a couple of parts I wish I could have fixed before I mounted the PC, but my impatience got to me and I needed to play some games – it's surprisingly hard to go without a computer for a month!

For example, I wish I'd tested the pump dampeners properly before mounting the PC – they're quiet, but not as quiet as I want at full load. You can clearly hear a high-pitched humming noise, but the humming stops when I play about with the pump dampeners and press on them. In the future, I'll find the time to properly fix them and make sure there's no noise before mounting the PC.

I also wish I could have fixed the long tube running from the RAM slots to the radiator. It isn't straight, as it was a very rushed job, plus I only had one shot as it was my last remaining tube! Again, my impatience got the better of me – I just really wanted to boot the whole thing up. CPC

BE A WINNER

To enter your machine for possible inclusion in Readers' Drives, your mod needs to be fully working and, ideally, finished based in the UK. Simply log on to **www.bit-tech.net** and head over to the forums. Once you're there, post a write-up of your mod, along with some pics, in the Project Logs forum. Make sure you read the relevant rules and advice sticky threads before you post. The best entrant each month will be featured here, where we'll print your photos of your project and also interview you about the build process. Fame isn't the only prize; you'll also get your hands on a fabulous selection of prizes – see the opposite page for details.

Win all these prizes!

We've teamed up with some of the world's leading PC manufacturers and retailers to offer this great range of prizes to each lucky Readers' Drives winner. If your creation is featured in the magazine then you'll walk away with all of the prizes listed on this page, so get in your entries!

Corsair graphite Series 230T case and RM 550w Modular power supply

TOTAL VALUE £150 inc VAT / **MANUFACTURER** www.corsair.com

Corsair believes that a great PC starts with a great case. The Corsair Graphite Series 230T is a compact expression of this core philosophy. With stylish looks and a choice of three different colours, it packs in a remarkable number of features to provide builders with tonnes of room for expansion and amazing cooling potential. Like all Corsair cases, it's built using the finest materials and finished to the highest standards, so it will withstand several years of upgrades. Plus, to make sure it stand outs from the crowd, the 230T features Corsair's new Air Series LED high-airflow fans, providing distinctive lighting with low-noise, high-airflow cooling.

Just as a quality case is essential to building a quality PC, a high-performance, a high-quality power supply is also a vital ingredient. The all new RM series has been built from the ground-up to deliver unmatched reliability alongside 80Plus Gold efficiency, and all with the absolute minimum of noise. It uses specially optimised quality parts to reduce sound at the component level, and it's completely silent below 40 per cent load, thanks to its Zero RPM fan mode. It's also fully modular, allowing for the maximum amount of flexibility during installation. With a Corsair Graphite 230T case and an RM 550W Modular power supply at the heart of your build, you'll have the foundations for a truly awesome gaming machine.

Mayhems coolant and dyes

VALUE £50 inc VAT / **MANUFACTURER** www.mayhems.co.uk

Cooling performance is only one part of the equation when it comes to kitting out your rig with custom water-cooling gear. The other major bonus is that all those tubes and gleaming fittings just make your PC look damn sexy, and they look even better when they're pumped full of fancy coloured coolant. As such, we're particularly pleased to have the folks at Mayhems now on board with Readers' Drives; they're currently offering two 1-litre bottles of Mayhems' Pastel Ice White coolant, along with a selection of five dyes, so you can choose the colour that best complements your PC. Check out the blue coolant in our own mini PC mod on the cover of Issue 109 for an example of what's possible with some Mayhems coloured coolant.

Phobya Modding Kit

VALUE £50 inc VAT **MANUFACTURER** www.phobya.com, www.aqua-tuning.co.uk

The Phobya modding kit is designed with the modder in mind, offering great value for money and quality products. The kit includes Nano-G 12 Silent Waterproof 1,500rpm multi-option fans, which use an innovative fan-blade design. As standard, the fans include braided black cables to keep your case looking as neat as possible. The fans are also supplied with a special cable that lets you run the fan at 5V rather than 12V, reducing the noise emitted in order to help you to build a silent system.

The kit also includes the 60cm Phobya 3-pin Molex to 4x 3-pin Molex Y-cable. This pre-braided extension cable gives you extra routing options in your case, and it also enables you to run up to four fans from one compatible motherboard header. Meanwhile, the Phobya SATA 3 cables included in the kit offer the same great quality braiding as the rest of the Phobya range, while also securing your connection with latched connectors.

As well as this, the kit includes the Phobya SlimGuide Controller, which gives you the option to vary the speed of other fans in your case, while the Phobya TwinLEDs let you shine a light on your mods.

DOWNLOAD FROM WWW.ASUS.COM/CAMPAIGN/REALBENCH

CUSTOM PC REALBENCH 2015

in association with ASUS

Give your PC a workout with our new benchmark suite, and see how your rig compares to other readers' machines

BENCHMARK YOUR PC

Download the benchmarks from www.asus.com/campaign/Realbench and, before you run them, disable any power-saving technologies in your BIOS that change your CPU clock speed, or the leaderboard won't record your overclock frequency properly. To post a score on the leaderboard, go to Save Upload File in the RealBench 2015 app's Results menu, and save your results in an RBR file. You need to select Offline Uploads on the leaderboard site, sign up for an Asus account and upload your file.

Gimp

We use Gimp to open and edit large images. Unlike our previous Gimp test, this one uses more than one CPU core, although it's still more sensitive to clock speed increases than more CPU cores.

Handbrake H.264 video encoding

Our heavily multi-threaded Handbrake video encoding takes full advantage of many CPU cores, pushing them to 100 per cent load.

LuxMark OpenCL

This GPU compute test is the only synthetic part of our suite, although the renderer is based on the real LuxRender physically based rendering software. As 3D rendering is a specific workload that not everyone will use, and because OpenCL support isn't standard in most software, this section is given just a quarter of the weighting of the other tests in the final score.

Heavy multi-tasking

Our new multi-tasking test plays a full-screen 1080p video, while running a Handbrake H.264 video encode.

Scores

RealBench 2015 breaks down the scores for each test, then gives you a total system score and a percentage reference score.

On an Intel system, the 100 per cent reference score comes from a stock-speed Core i7-4790K, with 16GB of Corsair 2,400MHz DDR3 memory, a 240GB OCZ 150 SSD, an Asus Maximus Gene VII motherboard and an Nvidia GeForce GTX 780 3GB graphics card.

On an AMD system, the 100 per cent reference score comes from a stock-speed A10-7850K APU, with 8GB of Corsair 2,133MHz DDR3 memory, a 256GB Plextor M5 Pro SSD and an Asus A88X-Pro motherboard, using the APU's integrated graphics. CPC

SHOUT OUTS!

First congratulations this month go to dubai1, who has managed to pump up his 8-core Core i7-5960X to 4.7GHz, enabling him to take our number five spot. Meanwhile, new entry dis80786 has nabbed the number 12 spot with a 4.4GHz Core i7-5930K, and second new entry mark.gee93 is just behind at number 13.

CHROME WARNING

At the moment, Google's Chrome browser flags up the RealBench 2015 download as potentially harmful, and we're aware of this issue. The file is perfectly safe, however – please ignore this warning.

CUSTOM PC REALBENCH 2015 LEADERBOARD

RANK	SYSTEM SCORE	REFERENCE	USERNAME	MOTHERBOARD	CPU	CPU CLOCK	MEMORY	PRIMARY GPU
1	275,683	240.9%	8pack	Asus Rampage V Extreme	Intel Core i7-5960X	5.5GHz	16GB Kingston 3000MHz	Nvidia GeForce GTX Titan X
2	233,375	203.9%	ian.parry3	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	32GB G.Skill 3200MHz	Nvidia GeForce GTX Titan X
3	219,638	191.9%	Chris_Waddle	Asus X99 Deluxe	Intel Core i7-5960X	4.6GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX Titan X
4	219,415	191.7%	Luke@DinoPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.6GHz	16GB Corsair 3276MHz	Nvidia GeForce GTX Titan X
5	215,694	188.5%	dubai1	Asus X99-Pro/USB 3.1	Intel Core i7-5960X	4.7GHz	32GB Corsair 2800MHz	Nvidia GeForce GTX 980 Ti
6	206,723	180.6%	stuart	Asus Rampage V Extreme	Intel Core i7-5960X	4.41GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 780 Ti
7	201,446	176.0%	CustomPC	Asus Rampage V Extreme	Intel Core i7-5960X	4.3GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX Titan X
8	197,964	173%	Carbonleg	Asus X99-E WS	Intel Core i7-5960X	Not reported	32GB Corsair 2400MHz	AMD Radeon R9 200 Series
9	189,230	165.3%	shadowsrayne	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Corsair 2133MHz	Nvidia GeForce GTX 980
10	185,219	161.8%	dax	Asus Rampage V Extreme	Intel Core i7-5960X	3.97GHz	32GB Corsair 2448MHz	Nvidia GeForce GTX 980
11	179,386	156.7%	mboogie	Asus Rampage V Extreme	Intel Core i7-5960X	4.2GHz	32GB Crucial 2133MHz	Nvidia GeForce GTX 980
12	175,745	153.6%	dis80786	Asus Rampage V Extreme	Intel Core i7-5930K	4.4GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX 970
13	173,154	151.3%	mark.gee93	Asus Rampage V Extreme	Intel Core i7-5930K	4.49GHz	12GB Corsair 3168MHz	Nvidia GeForce GTX 980 Ti
14	172,828	151%	mdottwo	Asus Rampage V Extreme	Intel Core i7-5820K	4.4GHz	16GB G.Skill 2766MHz	AMD Radeon R9 200 Series
15	167,332	146.2%	grozzie	ASRock X99M Killer	Intel Core i7-5930K	4.48GHz	32GB Kingston 3071MHz	AMD Radeon R9 200 Series
16	167,002	145.9%	maliepaard.chris	MSI X99S SLI Plus	Intel Core i7-5820K	4.49GHz	16GB Corsair 3000MHz	Nvidia GeForce GTX 980 Ti
17	165,512	144.6%	Penfold	Asus X99-Deluxe	Intel Core i7-5820K	4.5GHz	32GB Corsair 2333MHz	AMD Radeon R9 200 Series
18	163,650	143%	shaunhanson	MSI X99S SLI Plus	Intel Core i7-5820K	Not reported	16GB Corsair 2133MHz	Nvidia GeForce GTX 980
19	163,400	142.7%	andy	MSI X99S Gaming 7	Intel Core i7-5820K	4.4GHz	16GB Corsair 2666MHz	Nvidia GeForce GTX 980
20	163,065	142.5%	viperz	Asus X99-Deluxe	Intel Core i7-5820K	4.48GHz	16GB Corsair 2400MHz	Nvidia GeForce GTX 970

Folding@Home

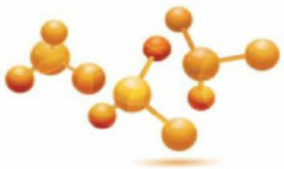
Join our folding team and help medical research

MILESTONES THIS MONTH

USERNAME	POINTS MILESTONE
AJJackson1	40000
Capt-Camm-Nett	60000
HiroMilo	70000
anfortis	200000
LEACHIE007	200000
Albie1971	300000
Ayeska	300000
p1ngu_666	300000
Valkerie69	300000
BenjieB	400000
grozzie	400000
Kentara	500000
mort6dav3	700000
bastardo_bill	800000
alien_ghost	900000
DJcarrot	900000
Quozzbat	1000000
smiler	1000000
TBTerra	1000000
jamiesp17	2000000
tastyradiskull	2000000
weebob	2000000
Bobthetoolnut	3000000
QuasarGreg	3000000
Damien_Tanner	4000000
ghodula	4000000
NikolaiDante	4000000
RaistlinRTCW	4000000
Trevrev	4000000
b1ll55t34m	5000000
bigrew	5000000
Scammelio	7000000
techknowledgey	7000000
coolamasta	8000000
centurion	9000000
Tommye123	9000000
andboo1	10000000
Bedders	10000000
Qazax	10000000
SirBenjaminNunn	10000000
Werewolf_Legs	10000000
admatt1980	20000000
Dave_Laffin	20000000
ForGrace	20000000
ChunkyBrother	30000000
Origami_Tsuki	30000000
slowpurple	30000000
daxchaos	40000000
Tattysnuc	40000000
Andy_J	50000000
Petaflops	50000000
sonic_vortex	50000000
Maglor	60000000
Cmaxx	70000000
8Core	80000000
HHComputers	600000000
Scorpuk	700000000

WHAT IS FOLDING?

Folding@home uses the spare processing cycles from your PC's CPU and graphics cards for medical research. You can download the client from **http://folding.stanford.edu** and our team's ID is 35947. Once you pass a significant milestone, you'll get your name in the mag. You can also discuss folding with us and other readers online at the **www.bit-tech.net** forums.



TOP 20 OVERALL

RANK	USERNAME	POINTS	WORK UNITS
1	Nelio	2,457,261,507	151,324
2	DocJonz	1,502,951,713	181,793
3	coolamasta	808,962,254	174,993
4	Scorpuk	713,369,634	29,975
5	piers_newbold	686,405,212	45,792
6	HHComputers	621,518,466	27,238
7	StreetSam	570,985,851	90,228
8	PC_Rich	497,029,488	80,072
9	Dave_Goodchild	465,719,482	119,794
10	johnim	445,677,678	81,658
11	Slavcho	383,416,933	35,067
12	Lordsoth	373,010,584	96,882
13	The_M2B	327,832,935	59,893
14	Laguna2012	278,176,681	23,122
15	phoenicis	250,044,587	95,660
16	Desertbaker	232,040,906	18,970
17	Wallace	212,477,027	6,204
18	zz9pzza	211,014,628	15,794
19	TheFlipside	209,230,287	22,466
20	KevinWright	194,875,016	30,683

TOP 20 PRODUCERS

RANK	USERNAME	DAILY POINTS AVERAGE	OVERALL SCORE
1	HHComputers	4,522,447	621,518,466
2	DocJonz	2,982,903	1,502,951,713
3	piers_newbold	1,284,285	686,405,212
4	Laguna2012	1,232,615	278,176,681
5	Lordsoth	1,190,254	373,010,584
6	Nelio	1,154,432	2,457,261,507
7	PC_Rich	870,274	497,029,488
8	Scorpuk	748,518	713,369,634
9	Dickie	725,994	144,111,140
10	daxchaos	713,232	47,309,184
11	KevinWright	671,657	194,875,016
12	Desertbaker	644,805	232,040,906
13	The_M2B	585,157	327,832,935
14	coolamasta	578,185	808,962,254
15	madmatt1980	547,516	26,187,691
16	Qazax	495,493	10,223,132
17	johnim	473,533	445,677,678
18	BeezaBob	458,440	69,497,627
19	Roveel	407,893	139,064,351
20	Tattysnuc	404,719	47,177,390

JAMES GORBOLD / HARDWARE ACCELERATED

I HAVE A CONFESSION TO MAKE ...

Until recently, James Gorbold hadn't built a new PC system from scratch for nearly four years

My job at Scan involves, among other tasks, R&D, so I spend a considerable amount of time testing early samples of upcoming components and software. However, until this weekend, I hadn't built a PC for almost four years. I do, of course, upgrade my main system at home on a regular basis, but the last time I took a complete set of factory-fresh components and assembled them together was way back in November 2011.

Doing so reminded me of one of the many reasons why I'm a PC enthusiast – I don't just get pleasure from using PCs but I also enjoying tinkering inside the case too. Like riding a bike, how to put all the parts together in the most efficient way quickly came back, and it amused me to see that, despite the passage of time, my cable-routing skills are still utterly woeful – just be glad I'm not building your 3XS PC.

One of the most striking aspects about building a system from scratch is how much easier it is now than in the past. For instance, only having one cabled storage bus (SATA) means you don't have to plan out where best to install all the various drives and cables for the myriad of buses that used to live alongside each other in our PCs (FDD, EIDE, SATA and even SCSI).

When speccing up the PC, I took what I thought was a risk in not using a third-party CPU cooler, but during the build, I found that the stock cooler Intel bundles with non-K edition CPUs is surprisingly quiet and quite adequate for a non-overclocked processor. Gone are the days of ridiculously noisy stock coolers that were best taken straight to the recycling plant.

The stock cooler Intel bundles with non-K edition CPUs is surprisingly quiet and quite adequate

Another discovery was the ability to multi-task. In the past, updating and configuring the BIOS was an attention-intensive process, with one wrong key press easily resulting in the motherboard turning into a paperweight. These days, this process is much easier – plus, I was able to multitask by using my monitor's Picture in Picture mode to configure the new system, while I could simultaneously continue my quest to breed the ultimate T-Rex in ARK: Survival Evolved.

Installing Windows from a USB stick is a hell of lot quicker than installing it from an optical disc too because, as regular readers will know, there's no optical drive in any of my PCs.

That said, while Windows 10 does install extremely quickly, and is a joy to use compared with Windows 8, I've disabled all of the routines that send back data to Microsoft about what files, emails and websites will be accessed on the new system. While this job pretty easy, it does strike me as a little underhand to make the 'share all data with Microsoft' type buttons so large and the 'no, I like my privacy' type buttons so small and tucked away in the other corner of the screen.

Still, being able to build a brand-new PC that will give me many years of faithful service, complete with software, in less than two hours isn't a bad ratio of work to reward, especially when the process itself was still genuinely pleasurable.

It's even started me thinking about building, as opposed to upgrading, my main PC, although I think I'm going to hold out until Nvidia's next-gen range of Pascal GPUs are released next year. CPC

James Gorbold has been building, tweaking and overclocking PCs ever since the 1980s. He now helps Scan Computers to develop new systems.

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